ESSO

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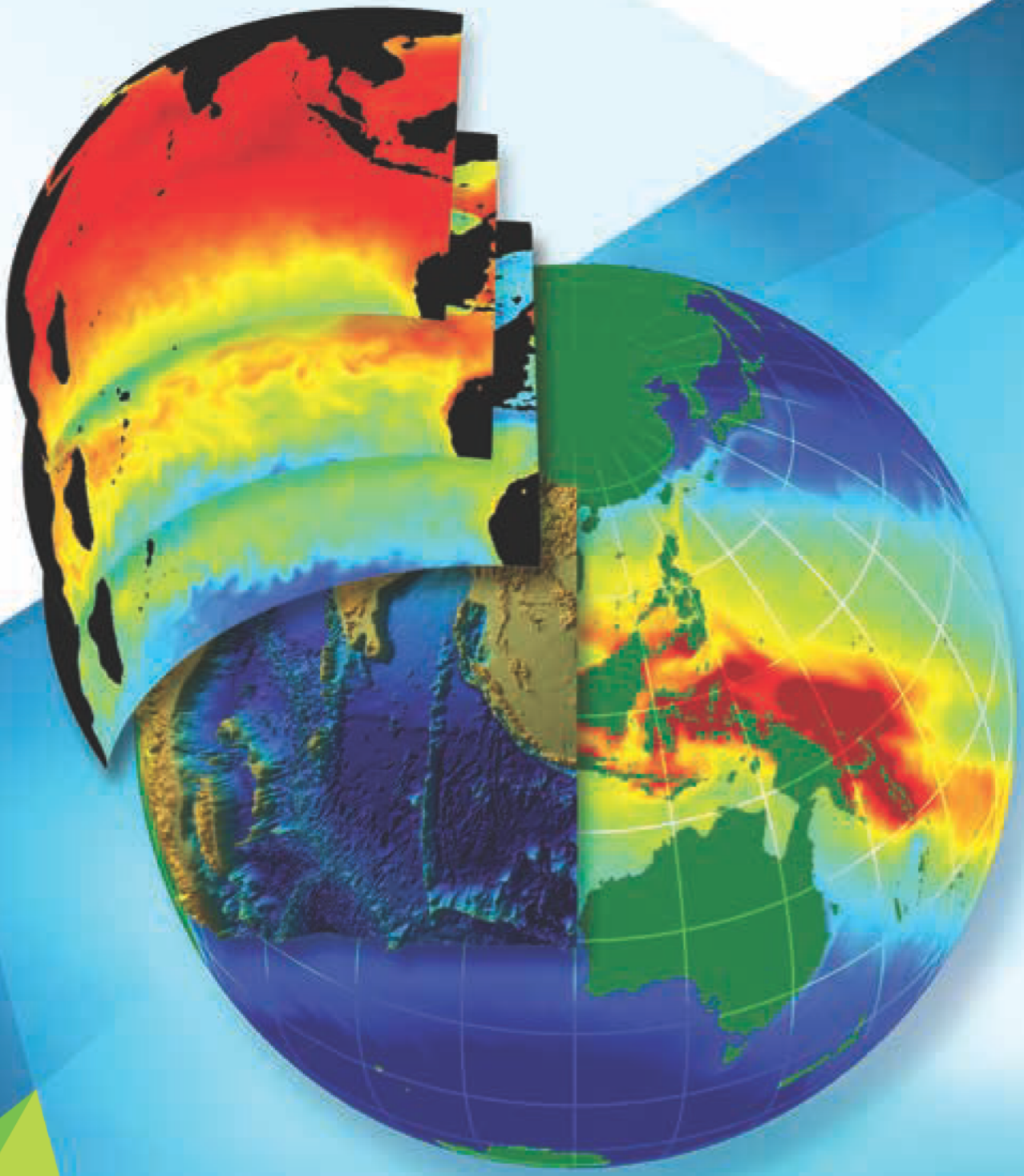
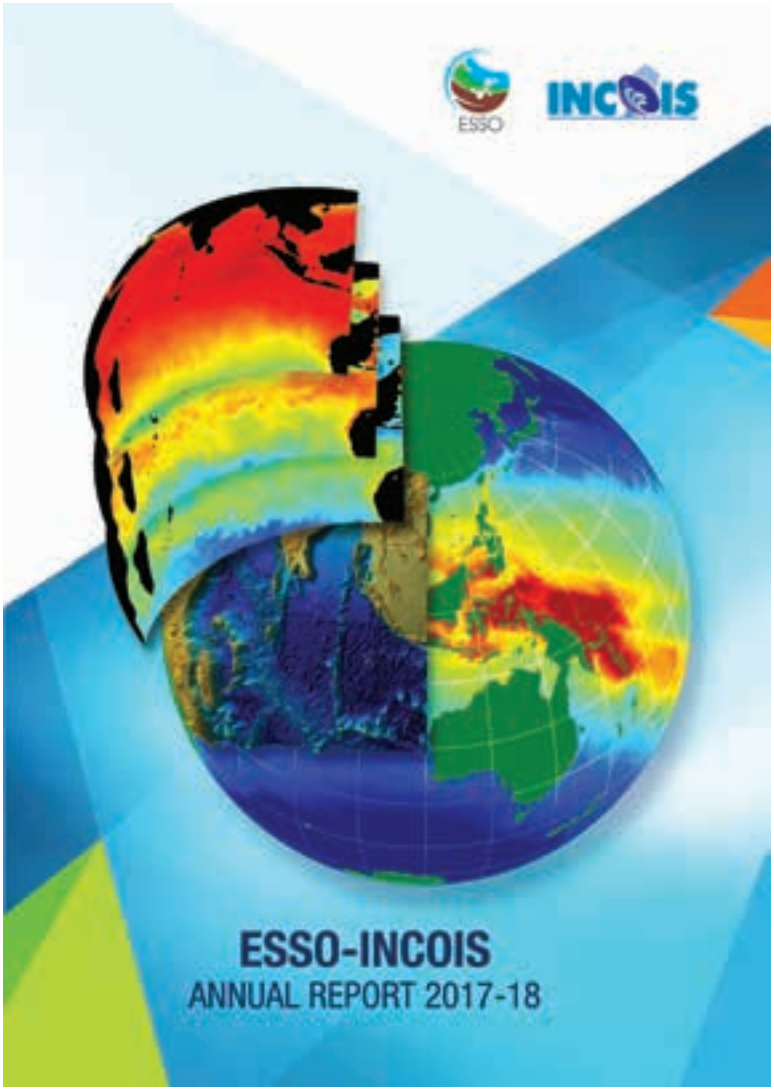


ESSO-INCOIS

ANNUAL REPORT 2017-18

Front Cover



Global simulation of sea surface temperature with overlay of Indian Ocean topography; Slices represent simulated temperature from high resolution ocean models of the Indian Ocean basin at the sea surface and then depths of 100 m and 200 m respectively.

Back Cover

Entrance to ESSO-INCOIS' Main Building

Photo Courtesy- Knowledge Resource Centre, ESSO-INCOIS

Annual Report 2017-18

ESSO-Indian National Centre for Ocean Information Services (INCOIS)
(An Autonomous body under Ministry of Earth Sciences, Government of India)
Hyderabad

Contents

From Director's Desk

Established in February 1999, INCOIS, India's leading Centre for operational oceanography and research in ocean science has leaped another year. Its success stems from the focused research and its application for socially relevant issues as written down in its mission statement: *"Provide the Ocean Information and Advisory Services to Society, Industry, Government Agencies and Scientific Community through Sustained Ocean Observations and Constant improvements through Systematic and Focussed Research"*. Our scientists and engineers just numbering 47 carry out research in improving the forecasts and warning systems in addition to understanding the dynamic process that shapes the behaviour of oceans and atmosphere. It gives me immense pleasure in presenting the Annual Report of ESSO- INCOIS for 2017-18 summarising the happenings and achievements. As in the past, the feedbacks that we received from various users remain as the testimony on the usefulness of our advisories, forecasts and early warnings.

We are happy that our strong emphasis on cutting edge research and training is attracting number of CSIR/UGC NET, INSPIRE qualified students seeking entry into INCOIS for Ph.D. research. At present, there are 12 doctoral students at INCOIS. Our efforts on training and capacity building in operational oceanography through the International Training Centre for Operational Oceanography (ITCOocean) is attracting more applications for the training course. During the last year (April 2017-March 2018), ITCOocean rejected 116 applications and trained 54 applicants through 3 training courses. The trainees were drawn from (Thailand, Sri Lanka, Seychelles, Indonesia, Vietnam, Mozambique, Kenya, Bangladesh, India). We are proud that the General Conference of UNESCO approved the establishment of ITCOocean as UNESCO Category 2 Centre and the Cabinet of Government of India met on 15 December 2017 and approved the signing of Agreement with UNESCO in establishing the Category 2 Centre. This international dimension would give India a leading role in ocean research and training.

Our efforts with the improvements in ocean models gave confidence to us in graduating PFZ advisories to PFZ forecasts. We could successfully operationalise another ocean general circulation model, Hycom, with a specialised data assimilation scheme to assimilate satellite derived SST and SSH and in situ profiles of T-S. Our team has successfully developed the Local Ensemble Transform Kalman Filter (LETKF) based assimilation scheme to assimilate data in ROMS model. The LETKF-ROMS assimilates in-situ temperature and salinity and sea surface temperature along satellite tracks.

The Tsunami Early Warning Centre monitored 30 earthquakes of magnitude ≥ 6.5 that occurred in the Global Oceans including the 2 earthquakes that occurred in the Indian Ocean and provided information as expected.

With the setup of TUNAMI-FF model for the global oceans, the Centre established the capability

in providing the tsunami early warnings for India and the countries on the Indian Ocean rim when a large earthquake occurs anywhere in the world oceans. We have also conducted a "Multi-State Mega Mock Exercise of Tsunami for East Coast of India" on 24 November 2017 in collaboration with NDMA and Ministry of Home Affairs (MHA). The exercise involved more than one lakh people.

The Multi-hazard Vulnerability Mapping for the Indian coast (mainland) has been completed and an integrated 3D visualization and analysis software also has been developed for the effective usage of the data for disaster management. A Marine Meteorological Atlas including the data collected by India Meteorological Department, NODPAC and other existing data sets has been prepared and released.

To enhance the timely reach of INCOIS advisories, forecasts and early warnings to varied users, an Integrated Information Dissemination System (IDS) named, *'Sagar Vani'*, was developed and launched at the hands of Dr. Harsh Vardhan, Hon. Minister for Science and Technology and Earth Sciences on the occasion of foundation day celebrations of Ministry of Earth Sciences on 27 July 2017.

With the launch of customized ocean state forecasts for Comoros, Mozambique, Mauritius and Papua New Guinea on 25 August 2017 by Dr. M. Rajeevan, Secretary, MoES during the 3rd Ministerial Meeting of Regional Integrated Multi-Hazard Early Warning System for Asia and Africa (RIMES), held at Port Moresby, Papua New Guinea, the number of countries to whom such services are provided by INCOIS/India has increased to 6.

INCOIS took up two scientific cruises (in June 2017 and January-February 2018) on board ORV Sagar Nidhi to study the small-scale turbulent characteristics of the upper water column and planetary boundary layer over the Bay of Bengal and Arabian Sea respectively. Three scientific cruises were organised on board RV Sagar Manjusha to record the variability in biogeochemical parameters in the coastal waters of the Bay of Bengal due to the impact of river water discharge and the coastal ecosystem prevailing there.

INCOIS scientists published 34 research papers in reputed national and international journals with a cumulative impact factor of 70.6. Dr. Praveen Kumar, Scientist D, was selected as Associate of Indian Academy of Sciences, Bangalore.

INCOIS also made conscious effort to reach out to other academic institutions and industry and fisheries departments in the coastal states. INCOIS signed MoUs with the Fishery Departments of Kerala and Odisha to disseminate the PFZ advisories to larger number of fishermen. An MoU was signed with Kerala University of Fisheries and Ocean Sciences (KUFOS), Kochi to promote the academic activities and research at both institutions. KUFOS recognised 8 scientists of INCOIS to supervise Ph.D. students. INCOIS carried out 4 consultancy projects for industry and ports.

The computational infrastructure at INCOIS has been upgraded by replacing the old 7.2 TF computer with a 33 TF computer. The construction of buildings for ITCOocean are also nearing its completion.

Prof. Appa Rao Podile, Vice Chancellor Hyderabad Central University delivered the foundation

day lecture. The "Open Days" on 27 July 2017 and 3 February 2018, attracted several hundred students and public to visit INCOIS facilities.

The Official Language Implementation Committee of INCOIS organised 3 seminars and 'Hindi Pakhwara' in September 2017. INCOIS organized Swachhta Pakhwara was organised during 16-30 June, 2017. Pakhwara activities included a cleanliness drive on the INCOIS entry road and cleaning of the Zilla Parishad School, Pragathi Nagar.

One scientific assistant was recruited on regular mode. Seven project scientists and 13 project assistants were recruited on contract basis to help the execution of projects. Two project scientists and 5 project assistants resigned/completed the term during the year.

ESSO-INCOIS continued its association with Indian Ocean Global Ocean Observing System (IOGOOS), Regional Co-ordination of Argo Programme, Partnership for Observation of Global Ocean (POGO), Regional Integrated Multi-hazard Early warning System (RIMES) and at Intergovernmental Coordination Group (ICG) of Indian Ocean Tsunami and other hazards Warning System (IOTWS) of Intergovernmental Oceanographic Commission (IOC)/UNESCO. INCOIS continued hosting the secretariats of IOGOOS, Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) and Ocean Bio-Informatics System (OBIS). In addition, the Indian node of Joint Programme Office (JPO) for IIOE-2 has been hosted at ESSO-INCOIS to coordinate the IIOE-2 project (2016-2020) jointly sponsored by IOC, SCOR and IOGOOS.

The continuous support and guidance received from the Governing Council under the chairmanship of Dr. M. Rajeevan are gratefully acknowledged. My thanks are also to the Chairs and members of Finance Committee and Research Advisory Committee for their critical comments and advices in conducting the financial and scientific affairs of ESSO-INCOIS. Colleagues in Ministry of Earth Science, especially the Programme Officer and his team, and at the MoES centres: NIOT, NCAOR, IITM, NCESS, NCMRWF, IMD, CMLRE, and NCCR were always there to support and solve the issues. I thank them all.

I would be remiss if I did not acknowledge the unflinching support from scientists, scientific assistants and the administrative staff in taking INCOIS where it stands today. Their continued support and cooperation will be crucial as we embark on future filled with challenges and endless opportunities. As for the previous issues of Annual Report, the members of the Editorial Committee Kiran, Hari, Praveen, Suprit, Ajay, Nimit, Celsa, Siddhartha and Greeshma under the chairmanship of Francis did a wonderful job.

I present this report for your enjoyable reading and comments. Thank you.

Jai Hind.

S. S. C. Shenoi

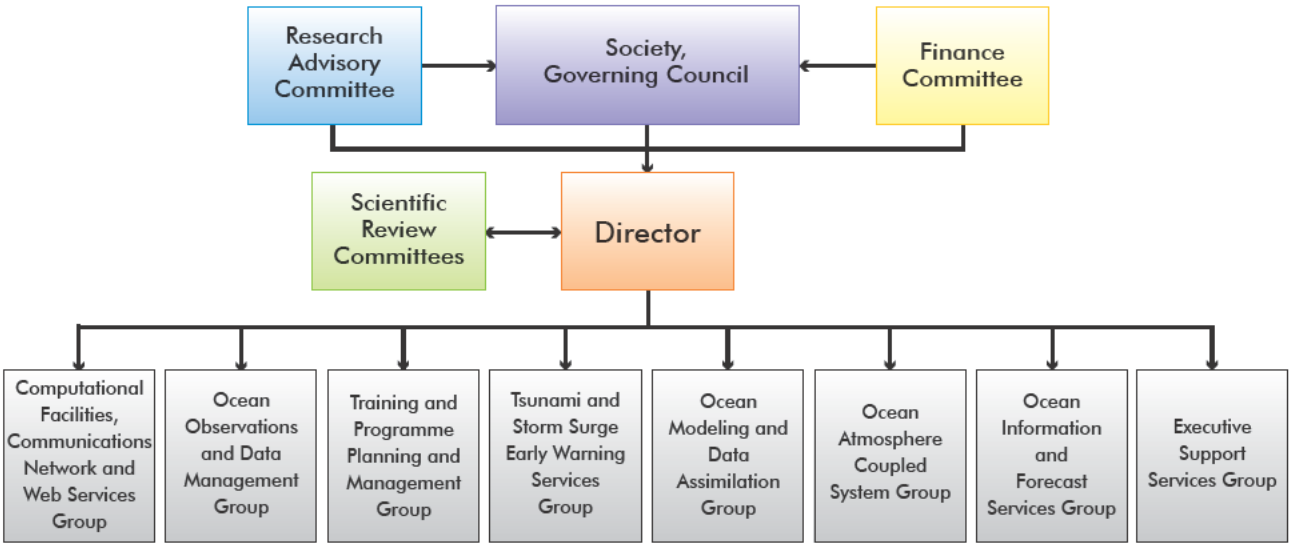
2. ESSO-INCOIS Organizational Structure

ESSO-INCOIS is an autonomous institute under the administrative control of Ministry of Earth Sciences (MoES), Government of India and a member of the Earth System Science Organization (ESSO).

ESSO-INCOIS was registered as a society under the Andhra Pradesh (Telangana) Public Societies Registration Act (1350, Falsi), at Hyderabad on 3 February 1999. The affairs of the society are managed, administered, directed and controlled by the Governing Council, subject to the Bye Laws of the Society.

2.1 ESSO-INCOIS Society

Secretary to Government of India, Ministry of Earth Sciences	President
Director, National Remote Sensing Centre, Hyderabad	Vice President
Joint Secretary, Ministry of Earth Science	Member
Advisor, Ministry of Earth Sciences	Member
Director, National Institute of Oceanography, Goa	Member
Director, National Institute of Ocean Technology, Chennai	Member
Director, National Centre for Antarctic and Ocean Research, Goa	Member
Director, Indian National Centre for Ocean Information Services	General Secretary



Organisation Structure of ESSO-INCOIS

2.2 ESSO-INCOIS Governing Council

1.	Secretary to Government of India, Ministry of Earth Sciences	(Chairman)
2.	Additional Secretary & Financial Advisor /Joint Secretary & Financial Advisor, MoES	(Member)
3.	Additional Secretary/ Joint Secretary, MoES,	(Member)
4.	Prof. G.S. Bhat, IISc Bangalore & Chairman, INCOIS-RAC	(Member)
5.	Dr. R.R. Navalgund, ISRO, Bangalore	(Member)
6.	Director, National Remote Sensing Centre	(Member)
7.	Director, Indian Institute of Tropical Meteorology	(Member)
8.	Director, National Institute of Oceanography	(Member)
9.	Head, National Centre for Medium Range Weather Forecasting	(Member)
10.	Programme Head (INCOIS), MoES	(Permanent Invitee)
11.	Representative, NITI Aayog	(Invitee)
12.	Director, Indian National Centre for Ocean Information Services	(Member Secretary)

2.3 ESSO-INCOIS Research Advisory Committee

1. Prof. G.S. Bhat, Indian Institute of Science (Chairman)
2. Dr. M. Dileep Kumar (Rtd.,), NIO (Member)
3. Dr. Prakash Chauhan, SAC (Member)
4. Dr. N.L. Sarda, IIT, Mumbai (Member)
5. Dr. Kusala Rajendran, IISc (Member)
6. Dr. M. Mohapatra, IMD (Member)
7. Dr. T.M. Balakrishnan Nair, INCOIS (Member - Secretary)

2.4 ESSO-INCOIS Finance Committee

1.	Additional Secretary & Financial Advisor /Joint Secretary & Financial Advisor, MoES	(Chairman)
2.	Additional Secretary/ Joint Secretary, MoES,	(Member)
3.	Programme Head (INCOIS), MoES	(Member)
4.	Director/Deputy Secretary (Finance), MoES,	(Member)
5.	Director, ESSO-INCOIS, Hyderabad	(Member)
6.	Dy. Chief Administrative Officer, ESSO-INCOIS, Hyderabad	(Member)
7.	Senior Accounts Officer, ESSO-INCOIS	(Member Secretary)

2.5 The Mission

To provide ocean data, information and advisory services to society, industry, the government and the scientific community through sustained ocean observations and constant improvements through systematic and focused research in information management and ocean modelling.

The major objectives of ESSO-INCOIS are:

1. To establish, maintain and manage systems for data acquisition, analysis, interpretation and archival for Ocean Information and related services.
2. To undertake, aid, promote, guide and co-ordinate research in the field of ocean information and related services including satellite oceanography.
3. To carry out surveys and acquire information using satellite technology, ships, buoys, boats or any other platforms to generate information on fisheries, minerals, oil, biology, hydrology, bathymetry, geology, meteorology, coastal zone management and associated resources.
4. To generate and provide data along with value added data products to user communities.
5. To cooperate and collaborate with other national and international institutions in the field of ocean remote sensing, oceanography, atmospheric sciences/meteorology and coastal zone management.
6. To establish Early Warning System for Tsunami and Storm Surges.
7. To support research centres in conducting investigations in specified areas related to oceanic processes, ocean atmospheric interaction, coastal zone information, data synthesis, data analysis and data collection.
8. To organise training programmes, seminars and symposia to advance study and research related to oceanography and technology.
9. To publish and disseminate information, results of research, data products, maps and digital information through all technologically possible methods to users for promoting research and to meet societal needs for improvement of living standards.
10. To provide consultancy services in the fields of ocean information and advisory services.
11. To coordinate with space agencies to ensure continuity, consistency and to obtain state-of-the-art ocean data from satellite observations.
12. To encourage and support governmental and non-governmental agencies/organizations for furthering programmes in the generation and dissemination of ocean information.
13. To undertake other lawful activities as may be necessary, incidental or conducive to the attainment and furtherance of all or any of the above objectives of ESSO-INCOIS.

2.6 Quality Policy

The ESSO-Indian National Centre for Ocean Information Services (ESSO-INCOIS), Earth System Sciences Organization (ESSO), Ministry of Earth Sciences (MoES) is committed to provide the best possible ocean information and advisory services to society, industry, the government and the scientific community through sustained ocean observations and constant improvement through systematic and focused research. To achieve this, we will continue to align our actions with organizational values & shall ensure our commitment to continually improve our performance with the Quality Management System, by setting and reviewing quality objectives.

3. Highlights

3.1. ITCOocean elevated as Category-II institute of UNESCO

The General Assembly of UNESCO held in November 2017 recognized International Training Centre for Operational Oceanography (ITCOocean) of INCOIS, as a UNESCO Category-2 Centre (C2C) for providing advanced training in operational oceanography for its member countries. Union Cabinet met on 15 December 2017 and granted permission to sign an MoU with UNESCO in this regard.

3.2. LETKF-ROMS For Operational Ocean Forecasts

INCOIS has successfully developed an ocean data assimilation system, designed for the operational configuration of Regional Ocean Modelling System (ROMS) in INCOIS. The newly developed assimilation system, LETKF-ROMS, is based on Local Ensemble Transform Kalman Filter (LETKF). LETKF-ROMS assimilates in situ temperature, salinity and satellite track data of sea surface temperature.

3.3. Ocean Forecasting System based on Hycom

A very high-resolution ocean forecast system based on the general circulation model, Hycom with data assimilation scheme based on Tentral Statistical Interpolation (T-SIS) scheme has been set up at INCOIS. The system assimilates in situ profiles of temperature and salinity and satellite estimates of SST and SSH.

3.4. Multi-hazard Vulnerability Mapping

INCOIS has completed the preparation of Multi-Hazard Maps for the Indian mainland, which consist of composite, synthesized and overlays of multiple hazards for coastal oceanogenic disaster management. INCOIS has also developed an integrated 3D visualization and analysis software for the effective usage of the data for disaster management.

3.5. Marine Meteorological Atlas (MaMeAT)

Prepared a Marine Meteorological Atlas, which includes several unique records of marine meteorological data collected by India Meteorological Department, NODPAC and the individual data records obtained from ICOADS. These data sets were processed, quality controlled and merged to form a unique data set to enhance the marine met climatology of Indian Ocean.

3.6. Operational Tsunami Early Warnings for Global Earthquakes

INCOIS has configured a global setup of TUNAMI-FF model for the numerical simulation of Tsunami in the event of earthquakes in the global oceans. TUNAMI-FF model is capable of simulating all the stages of a tsunami including its origin, propagation in the ocean, arrival times at different coasts and wave amplitudes at beach (~ 1 m water depth). With this capability, ITEWC is able to provide tsunami early warnings for Indian within 15-20 minutes of an earthquake happening in the oceans outside Indian Ocean.

3.7. **Mega-Mock Tsunami Drill for the East Coast of India**

INCOIS conducted a "Multi-State Mega Mock Exercise of Tsunami for East Coast of India" on 24 November 2017 in collaboration with NDMA and Ministry of Home Affairs (MHA). More than 350 villages from 32 coastal districts of east coast of India participated in the mock exercise and more than one lakh people were involved and evacuated during the mock drill.

3.8. **Process Specific Observations in Bay of Bengal and Arabian Sea**

As part of INCOIS efforts to understand and model the upper ocean mixing processes, two scientific cruises (April 2017 and March 2018) were conducted on board ORV Sagar Nidhi to collect near-surface meteorological data, upper ocean temperature, salinity, vertical distribution of small-scale turbulent characteristics and to document planetary boundary layer characteristics in the Bay of Bengal.

3.9. **Pilot cruises for MOSAIC programme**

Three pilot scientific cruses for the upcoming MOSAIC programme were conducted in the waters of east coast of India. Main objectives of the cruises were to capture the variability in biogeochemical parameters in the coastal waters of the Bay of Bengal, studying the impact of river water discharge on coastal ecosystem at select locations, understand physical-biological interactions in the coastal waters and to develop algorithms to derive geophysical parameters for coastal waters.

3.10. **Ocean State Forecast Services for Island Nations**

INCOIS started to issue customized Ocean state forecasts for Comoros, Mozambique, Mauritius and Papua New Guinea from August 2017. The new systems were unveiled on 25 August 2017 by Dr. M. Rajeevan, Secretary, MoES during the 3rd Ministerial Meeting of Regional Integrated Multi-Hazard Early Warning System for Asia and Africa (RIMES), held at Port Moresby, Papua New Guinea.

3.11. **SAGAR VANI: Integrated Dissemination System**

INCOIS developed an Integrated Information Dissemination System (IDS), named 'Sagar Vani', for facilitating effective and timely dissemination of ocean information/forecasts/ advisories directly from INCOIS to the end users. 'Sagar Vani' was formally launched on 27 July 2017 by Dr. Harsh Vardhan, Hon. Minister for Science and Technology and Earth Sciences on the occasion of 12th foundation day celebrations of Ministry of Earth Sciences.

3.12. **Computing Infrastructure**

The computational infrastructure of INCOIS has been upgraded by replacing the old 7.2 TF HPC facility with a new 33 TF HPC. The new HPC is being used for the operational R & D activities.

3.13. **Associate of Indian Academy of Sciences**

Dr. Praveen B. Kumar, Scientist D, was selected as Associate of Indian Academy of Sciences, Bangalore.

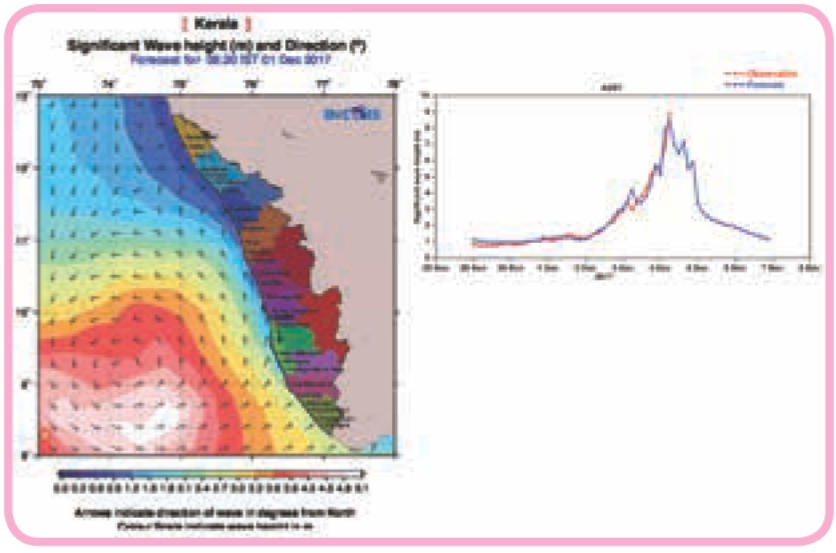
4. Services

4.1. Ocean State Forecast Services

Ocean State Forecast service, one of the flagship programmes of INCOIS, provides information and forecasts on various oceanographic parameters such as waves, currents, tides, sea surface temperature, mixed layer depth etc. on a daily basis. In the event of extreme weather conditions, OSF services are provided more frequently with specific advisories on the impact of such weather conditions on life and properties of those who venture into the seas or live near the seashore. The forecasts are generated using a suite of state-of-the-art numerical ocean models configured specifically for the Indian Ocean domain and the coastal waters around the country. The forecasts and advisories are prepared using these models in conjunction with real-time observational networks and disseminated as various products in local languages. Ocean State Forecast services are also rendered to six island nations in the Indian Ocean. Important milestones of OSF services in the past one year are the following.

4.1.1. Ocean State Forecast during Very Severe Cyclonic Storm "Ockhi"

INCOIS issued the warning messages during the very severe cyclone "Ockhi", which passed off the southern coast of India starting from 28 November 2017 onward. More than two lakh users on the west coast were alerted directly through mobile SMS about the possibility of rough seas during the passage of cyclone. INCOIS also issued 24 joint bulletins with IMD during the passage of cyclone with updated features of the system and the conditions in the underlying ocean. The predictions of extreme wave conditions were validated in real time with the data obtained from the directional wave rider buoy deployed by NIOT in the Arabian Sea.



Left: Significant wave height and direction forecast issued by INCOIS during the passage of Okchi cyclone . Right: A comparison of significant wave height predicted by INCOIS with the observation from NIOT moored buoy AD07 during the passage of cyclone Okchi.

Apart from cyclone Okchi, Joint INCOIS-IMD Bulletins with ocean state forecast and cyclone details were issued to all concerned coastal states during the passage of cyclone *Maarutha* that formed in the east central Bay of Bengal (15-17 April 2017), Depression in the western Bay of Bengal (15-17 November 2017), and also Deep Depression in the Bay of Bengal (4-9 December 2017) and the depression that formed south of Sri Lanka (12-15 March 2018).

4.1.2. Alerts during perigean spring tide

A perigean spring tide is a tide that occurs when the Moon's perigee coincides with the spring phase of the tide. Perigean spring tides are usually associated with higher water levels, stronger currents and inundation of low-lying areas. INCOIS issued specific localized alerts on the occurrence of perigean spring tides and associated wave/current features for the coasts of Kerala, Goa and West Bengal during 3-5 January 2018. It has been reported that the water levels, waves and currents in these areas were unusual as predicted by INCOIS.

4.1.3. Ocean State Forecast Services for Island Nations

INCOIS has been extending the OSF services to the Indian Ocean Rim countries; Maldives from 2013 onwards and Sri Lanka and Seychelles from 2015 onwards. INCOIS started to issue customized Ocean state forecasts for four more countries (Comoros, Mozambique, Mauritius and Papua New Guinea). The new systems were unveiled on 25h August 2017 by Dr. M. Rajeevan, Secretary to Government of India, Ministry of Earth Sciences in the presence of David Grimms, President of World Meteorological Organization (WMO) and the ministers and officials of RIMES member countries during the third Ministerial Meeting of Regional Integrated Multi-Hazard Early Warning System for Asia and Africa (RIMES), held at Port Moresby, Papua New Guinea. Forecast and early warming information on high wave, currents, winds, tides, sea surface temperature and several sub-surface ocean parameters are being disseminated through dedicated OSF portal.

Inauguration of Ocean State Forecast Services for Comoros, Mozambique, Mauritius and Papua New Guinea

4.1.4. Mobile App for Search and Rescue Aid Tool (SARAT)

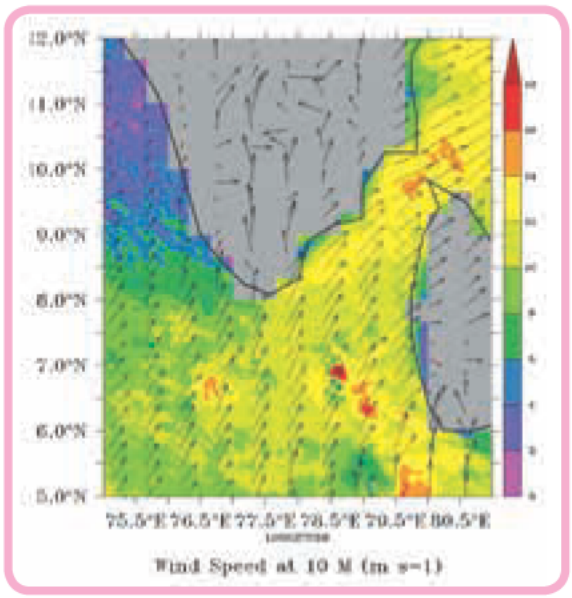
INCOIS developed a mobile app for the easy access of the Search and Rescue Aid Tool (SARAT), a utility developed in-house for locating missing/lost objects in the sea. The SARAT App was released by Shri. Rajendra Singh, Director General Indian Coast Guard and Chairman, National Maritime Search and Rescue (NMSAR) Board during the XVI National Maritime Search And Rescue Board Meeting held in New Delhi on 10 July 2017.

A screen-shot of SARAT mobile App (left) and a sample advisory based on (right)

4.1.5. Kondalkattu Alert

Kondalkattu Alert (high wind condition off and along the coast of Tamil Nadu) was issued on 18 May 2017 indicating the possibility of

heavy winds (15-20 ms^{-1}) and high waves (2.5-3.5 m) particularly off the coast of Kolachal to Rameswaram during 2030 hrs on 18 May 2017 to 0530 hrs of 19 May 2017. Feedback received suggested that the alerts were accurate and many fisherfolk could save their livelihood assets without much damage due to the prior information (Ref: Email communication from MSSRF).



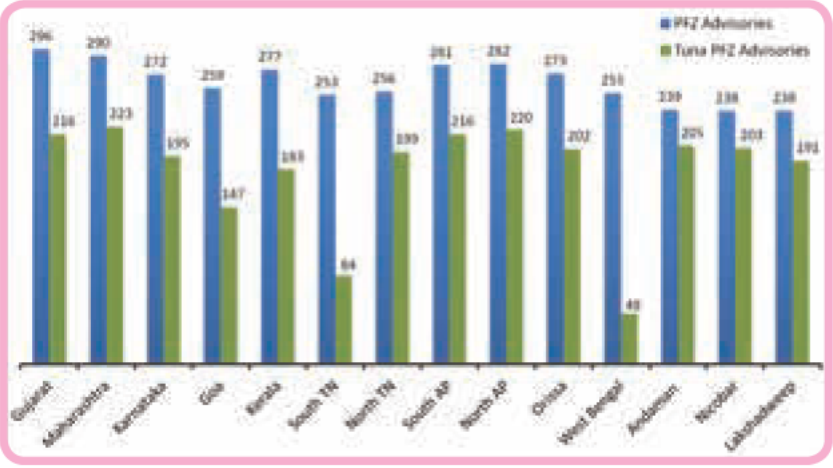
Predicted wind speed (ms^{-1}) and direction using WRF model for 18 May 2017 2030 IST.

4.1.6. NavIC Satellite Programme

INCOIS, in collaboration with ISRO successfully tested a technology to disseminate INCOIS services (OSF, PFZ, tsunami warnings) to users in the ocean through the NavIC satellite system of ISRO. Information for 3 locations in Kerala were disseminated through NavIC system during 4-6 January 2018. It was reported that the test messages sent to the boats in the deep ocean were received without fail. This collaborative programme of ISRO and INCOIS will be an effective method for alerting the fisherfolk/mariners in the open ocean about adverse weather conditions. A training on "INCOIS services direct to the open ocean through the ISRO satellite NAVIC" was conducted by INCOIS for the Fisheries Department officials (trainers) and selected fisherfolk of Kerala on 31 January 2018 at Thiruvananthapuram.

4.2 Marine Fisheries Advisory Services (MFAS)

4.2.1. Potential Fishing Zones (PFZ) and Tuna PFZ Advisories



Number of PFZ and Tuna PFZ advisories issued during April 2017-March 2018

INCOIS continued to provide its flagship service of Potential Fishing Zone (PFZ) advisories, which contains information on the regions of fish availability. PFZ advisories are generated based on the satellite data of Sea Surface Temperature (SST) and ocean colour along with other environmental parameters such as water clarity and sea level.

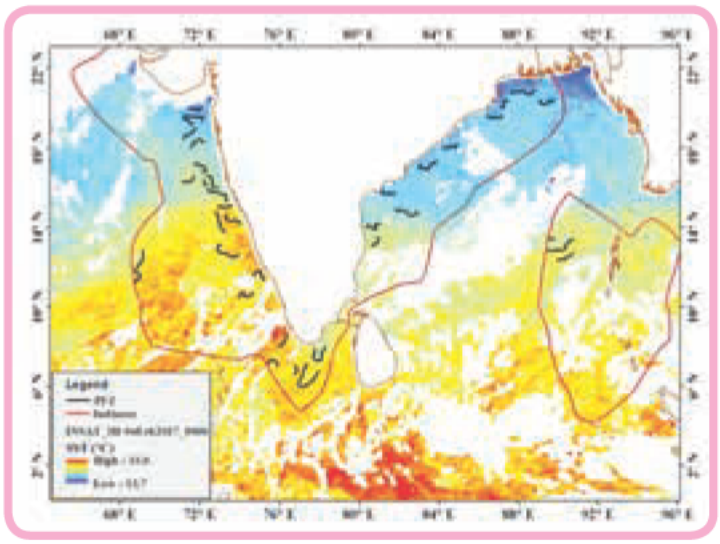
The advisories are being disseminated in smart map and text form on daily basis, depending on satellite data availability, except fishing-ban period and during adverse sea-state. During the period April 2017 to March 2018, multilingual Potential Fishing Zone (PFZ) advisories were made available on 348 days. In addition, during the FY 2017-18, INCOIS provided 248 Tuna advisories,

Growth of INCOIS MFAS user-base over the years (numbers in Lakhs)

that included information on the maximum fishing depth.

Identification of PFZs using data from geostationary satellites

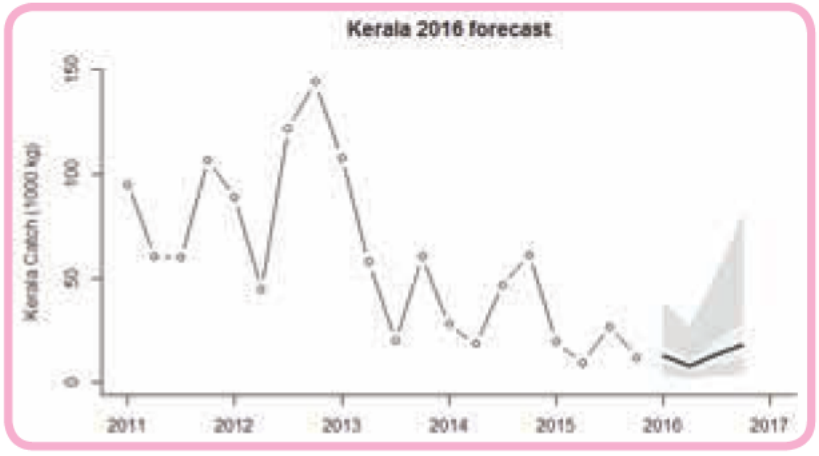
With an aim to reduce the dependency on the data from polar orbiting satellites (POS), INCOIS explored the possibility to utilise the SST data from Indian weather satellites such as INSAT 3D and INSAT-3DR in the geostationary orbit. While the POS can provide one or two scenes in a day for the region, a geostationary satellite can provide the image every half an hour. The advantage of using data from two geostationary satellites includes high temporal resolution of SST data (every 15 min) with spatial resolution of 4 km. In order to test the feasibility of using geostationary satellite SST data received from ISRO, sample PFZ advisories were generated in-house. This is being further pursued in collaboration with ISRO.



A sample PFZ advisory map generated using SST data from INSAT-3D.

4.2.2. Species specific research efforts

4.2.2.1. Indian Oil Sardine

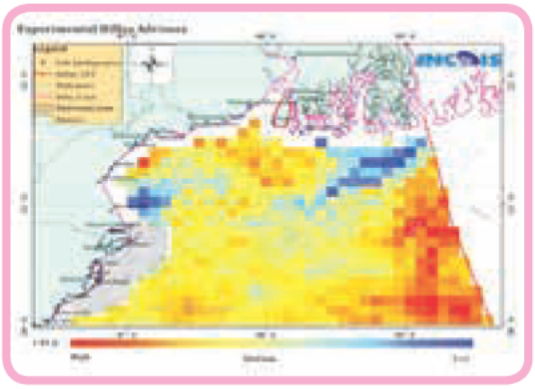


Sample output of the statistical predictive model showing the predicted Indian Oil Sardine catches for Kerala state in year 2016. The lighter and darker shadows indicate 80% and 30% error margins, respectively.

A statistical model, based on historical landing records was developed to predict the availability of Indian Oil Sardine, in collaboration with CMLRE and NOAA (USA) under the framework of NOAA-MoES technical cooperation. This model was successfully tested for the prediction of the Indian Oil Sardine *(Sardinella longiceps)* landings in Kerala. Further R&D is progressing to include in situ and other observations to refine the model further.

4.2.2.2. Hilsa Shad

A new small-pelagic fish habitat-suitability model has been developed to predict the potential fishing zone for the Hilsa shad *(Tenualosa ilisha)*, which is generally seen in the northwestern parts of the Bay of Bengal. Hilsa habitat was studied from the catch data and oceanic/ecological indicators derived from an operational biophysical model and remote sensing data. Sea surface temperature (SST), chlorophyll concentration (CC), dissolved oxygen (DO) and salinity data from the Regional Ocean Model System (ROMS) simulations and remotely sensed rainfall data were used as predictor variables in the model.



A sample of experimental Hilsa PFZ advisory

Several generalized additive models were constructed with Hilsa shad Catch per Unit Effort (kg h^{-1}) as a response variable for the study period (2009-2016). Best-fit model was used to predict catch per unit effort (CPUE) of Hilsa shad using predictor variables and the model was validated using a linear model. Probability maps of predicted habitat with no fishing zone information are being generated using geographic information system.

4.3. Dissemination of OSF and PFZ Services

4.3.1. SAGAR VANI: Integrated Dissemination System

In order to facilitate effective and timely dissemination of ocean information/forecasts/advisories directly from INCOIS to end users, an Integrated Information Dissemination System (IDS), 'Sagar Vani', has been developed. 'Sagar Vani' is a software platform where various dissemination modes will be integrated on a single central server. The IDS includes multilingual SMS, voice call/audio advisory, mobile apps (user/admin modules), social media (Facebook, Twitter, etc.), email, GTS, fax, digital display boards, radio/television broadcast units, IVRS, cloud channels, etc. The system also has the facility to provide access to various stakeholders (NGOs, State Fishery Departments, Disaster Management Authorities, etc.) so that they too will be able to further disseminate the ocean information and alerts to the end users. Sagar Vani was launched on 27 July 2017 by Dr. Harsh Vardhan, Hon. Minister for Science and Technology and Earth Sciences on the occasion of 12th foundation day celebrations of Ministry of Earth Sciences.

Launch of 'Sagar Vani' by Dr. Harsh Vardhan, Hon. Minister for Science and Technology and Earth Sciences on the occasion of 12th foundation day celebrations of Ministry of Earth Sciences.

4.3.2. Digital Display Systems: The new-generation of Electronic Display Boards

One of the most popular means by which the ocean information/advisories/forecasts from INCOIS are disseminated is through the Electronic Display Boards (EDBs) installed at several fishing harbours along the coast. The EDBs installed several years back are now being replaced in a phased manner by a set of new EDBs, known as Digital Display Systems (DDS). These DDS are powered by solar panels and supported by dissemination software developed in-house. The installation of the DDS for Kerala was inaugurated by Smt. J. Mercykuttiyamma, Hon. Minister of Fisheries, Govt. of Kerala during SAFARI-2 symposium organized by CMFRI, Kochi, in January, 2018. As of 31 March 2018, installations of 66 DDS have been completed in addition to already existing 72 EDBs.

New generation of EDB, knows as DDS (upper-left) are powered by solar energy (upper-right), and are being installed across the Indian coastline to enrich existing constellation of EDBs (lower panel, EDB in blue and DDS in red).

4.3.3. Outreach and Capacity Building

INCOIS conducted four user interaction and capacity building programmes at different parts of the country to increase awareness on services among the coastal population. One such programme was held in Okha harbour, Gujarat during 19-20

Dr. T. M. Balakrishnan Nair (Head, ISG) delivering keynote talk on INCOIS services during special user-interaction session during SAFARI-2.

Fishermen interaction with INCOIS scientist at markets and jetties of Okha, Gujarat.

March 2018 to increase awareness on INCOIS services among the coastal population. A special user-interaction session on disaster management in Malayalam was organized during SAFARI-2 symposium at CMFRI, Kochi, in February 2018.

It was observed that the advisories provided through SMS and Mobile App are more efficient to reach the users. INCOIS signed Memorandum of Understandings with State Fisheries Departments of Odisha and Kerala. The broad scope of MoU includes (i) installation of Electronic Display Boards with fisheries departments (ii) collection of mobile numbers of fishermen from the fisheries departments and INCOIS to provide its services through SMS, (iii) local support by fisheries departments towards capacity building of fishery officials as well as fishermen community. Further, INCOIS renewed the MoU with TCS for the dissemination of OSF and PFZ services through its mKrishi® platform.

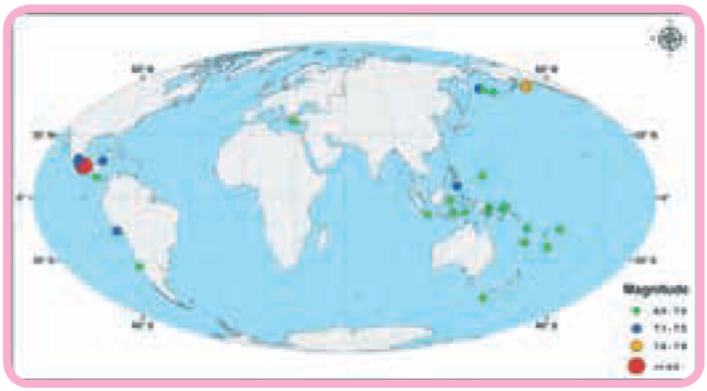
User interaction workshop at Krishnapatnam on April 3, 2017.

MoU signed between INCOIS and Odisha government for the dissemination of OSF and PFZ services to fishermen on 15 April 2017.

MoU signed between INCOIS and Kerala State Fisheries Department for the dissemination of OSF and PFZ services to fishermen on 24 October 2017.

4.4. Tsunami and Storm Surge Early Warning System

Indian Tsunami Early Warning Centre (ITEWC) monitored 30 earthquakes of magnitude ≥ 6.5 during the period April 2017 to March 2018. Out of these 30 earthquakes, only 2 major earthquakes had occurred in the Indian Ocean region. For all these earthquakes, ITEWC disseminated the bulletins to all regional and national stake holders through Email, FAX, GTS and SMS.

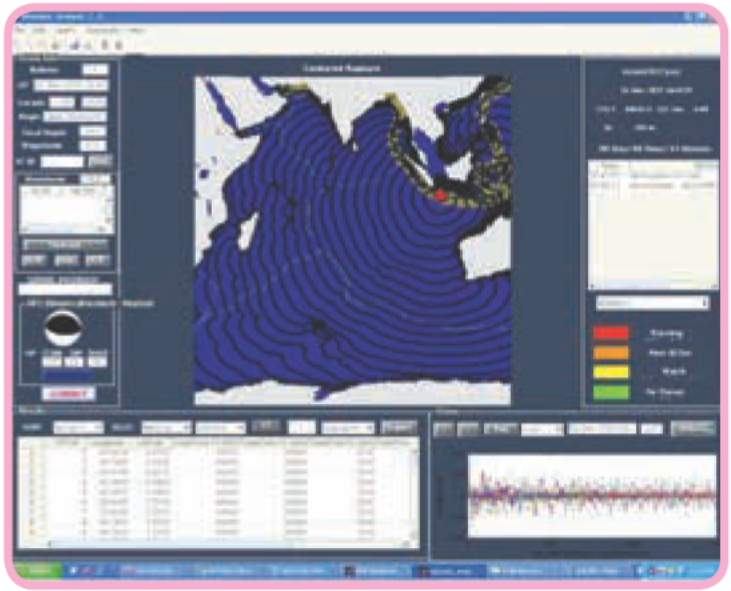


Locations of earthquakes with magnitude >= 6.5 Mw occurred in the global oceans

4.4.1. Performance indicators of ITEWC

Sl. No	Performance Indicator	Target	ITEWC Performance (till 31 March 2018)
PI 1	Elapsed time of issuing first bulletin after earthquake	10 min	10min
PI 2	Probability of Detection of IO EQ with Mw >= 6.5	100 %	100%
PI 3	Accuracy of Earthquake Parameters, in comparison with final estimates from USGS		
(a)	Magnitude	0.3	0.1
(b)	Depth	25 km	14.7km
(c)	Location	30 km	10.3 km
PI 4	Elapsed time of issuing first tsunami threat assessment bulletin after earthquake	20 min	25 min
PI 5	Probability of detection tsunamis above threat threshold	100%	100%
PI 6	Accuracy of tsunami wave height predictions	Factor of 2	NA

An earthquake having a magnitude of 6.8 Mw occurred near the coast of Java, Indonesia (7.95°S, 108.02°E) at 22:17hrs on 15 December 2017. Based on pre-run model scenarios, ITWEC issued a NO THREAT bulletin for the coastline of India.



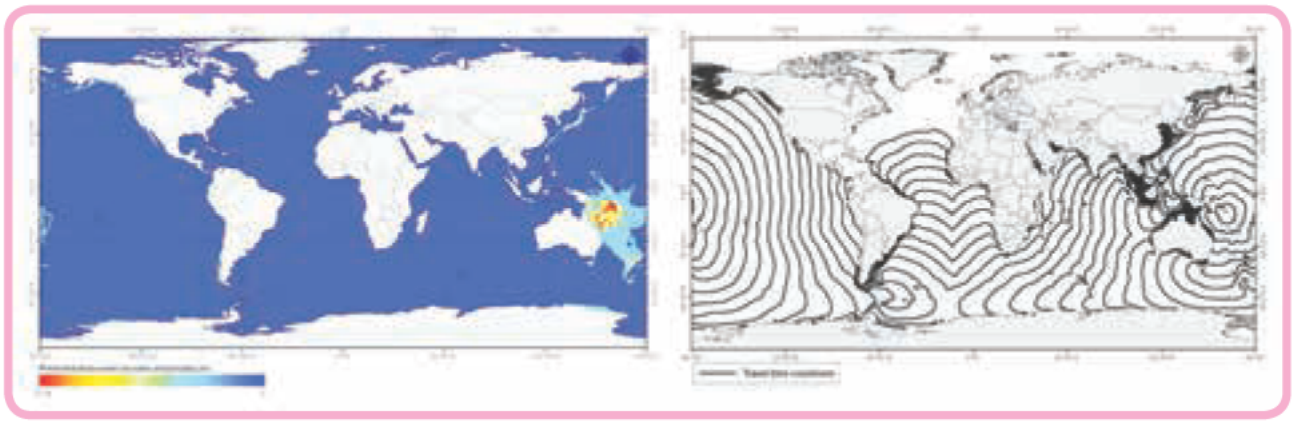
Operational model forecasts during major event on 15 December 2017

Performance indicators of ITEWC in monitoring Java Earthquake on 15 December 2017.

Time (UTC)	Event	Elapsed Time from EQ Origin Time (min)
1647	Earthquake Occurrence	0
1652	Earthquake Detection by SEISCOMP	5
1657	Type - I Bulletin Issue	8
1658	Closest Scenario Pickup & Results (Situation Analysis)	9
1712	Type – II NO THREAT Bulletin Issue (FINAL)	25

4.4.2. Operational Tsunami Early Warnings for Global Earthquakes

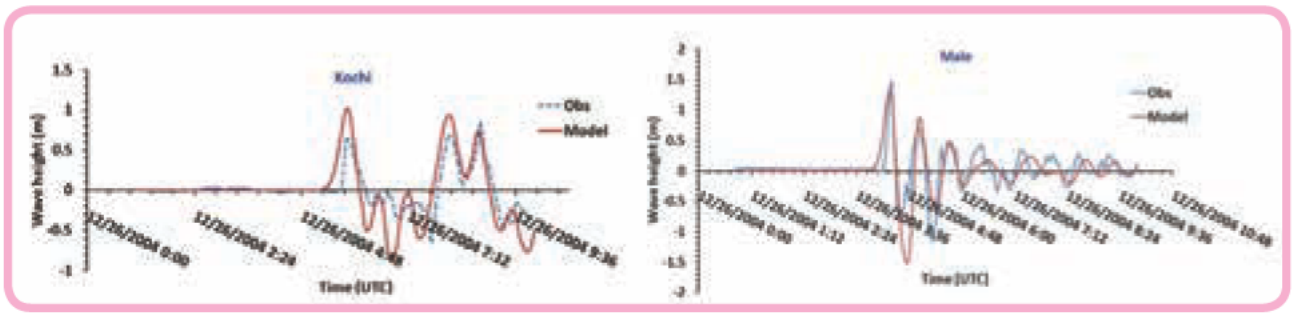
ITEWC has configured a global setup of TUNAMI-FF model for numerical simulation of Tsunamis in the event of earthquakes in the global oceans. TUNAMI-FF model simulates all stages of a tsunami from its origin, including propagation in the ocean and arrival times at different coasts and wave amplitudes at beach (~ 1 m water depth). This model has been made operational for the prediction of Tsunami in real time in the global oceans. At present, this model takes 15-20 minutes to complete a real- time early warning of tsunami. ITEWC got an opportunity to



Simulations of tsunami propagation and travel time by the global Tsunami-FF model.

test the TUNAMI-FF model to predict the characteristics of the Tsunami in real time during the tsunamigenic earthquake that occurred on 15 December 2017 near the coast of Java, Indonesia.

4.4.3. Tsunami and Storm Surge Inundation Modelling



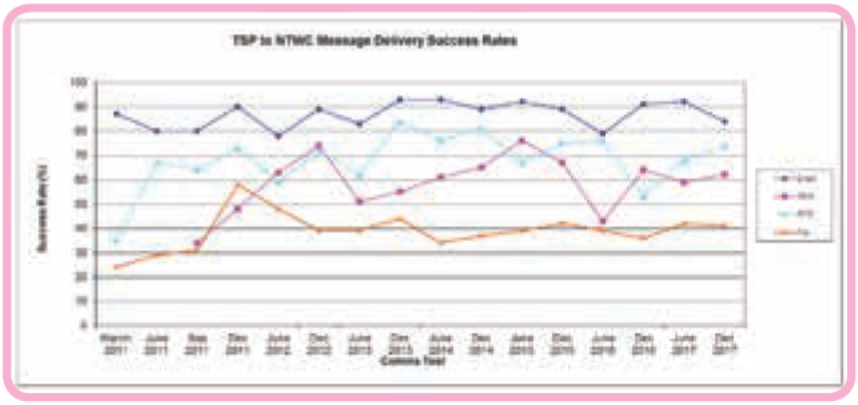
Comparison of tide gauge observations with tsunami wave heights at Kochi and Male simulated by ADCIRC model for the December 2004 event.

An ADCIRC-based tsunami and storm surge inundation modelling framework for the Indian Ocean domain has been developed in-house for providing operational tsunami warnings. Twenty-four-hour long simulation of tsunami propagation based on this model for the Sumatra and Makran subduction zones were performed. A case study of inundation due to the 26 December 2004 Indian Ocean tsunami showed that the model simulations of wave heights and inundation are in very good agreement with the observations. It was found that, at all tide gauge locations the crest of tsunami wave arrived initially. This is an observed feature along the locations west of the source of the earthquake. Also, the simulated arrival time, phase and wave periods at all locations were in good agreement with the observations. The model simulations at a few locations require improvements through the incorporation of surveyed bathymetry.

4.4.4. Communication Tests & Tsunami Workshops

a) COMMs Test

Two COMMs tests (on 14 June 2017 & 13 December 2017) were conducted to validate the TSPs dissemination process to NTWCs, validate the dissemination processes for tsunami notification messages with national disaster management contacts, reception of the notification messages by NTWCs and the access of the websites of TSP by NTWCs. During the COMMs tests, on 14 June 2017 ITEWC messages were disseminated to 25 NTWCs and the other TSPs (Australia & Indonesia) in the Indian Ocean about a simulated tsunami event triggered by an earthquake of magnitude 9.0 Mw near Nicobar Islands. ITEWC received notification messages from other TSPs as well. During the COMM test conducted on 13 December 2017, similar dissemination of messages to 25 NTWCs and the other TSPs (Australia & Indonesia) were done about a simulated tsunami event triggered by an earthquake of magnitude 9.2 Mmw near Northern Sumatra islands.



Success rate of message deliveries during the COMMs Tests since 2011

b) Tsunami Sensitization Workshops

Two tsunami sensitization workshops, one in preparation for the Tsunami mock drill for the east coast of India, for Andhra Pradesh State Disaster Management Authority on 26 September 2017 at Vijayawada and another one for the Directorate of Disaster Management, Andaman & Nicobar Islands at Port Blair on 13 December 2017 were conducted.

Participants of tsunami sensitization workshop at Vijayawada

INCOIS also organized the Tsunami Standard Operating Procedure

Participants of tsunami sensitization workshop at Port Blair

(SOP) workshop in collaboration with National Disaster Management Authority (NDMA) for Disaster Management Officers on 8 November 2017 at INCOIS, Hyderabad. A table-top exercise was also conducted for the participants. Another table-top exercise was conducted for the officials of Western Naval Command at Karwar on 18 May 2017 as part of the joint HADR exercise.

Participants of SOP workshop on 8 November 2017 at INCOIS

c) *Mega-Mock Tsunami Drill for the East Coast of India*

INCOIS conducted "Multi-State Mega Mock Exercise of Tsunami for East Coast of India" on 24 November 2017 in collaboration with NDMA and Ministry of Home Affairs (MHA). More than 350 villages from 32 coastal districts on the east coast of India participated in the mock exercise and more than one lakh people were involved and evacuated the mock drill. Participants from Pacific Islands countries, who were attending the INCOIS-MEA-NDMA training programme on

Mega-Mock Tsunami Drill for the east coast of India

"Early Warning System for Oceanic disaster and mitigation with special emphasis on tsunamis", witnessed the mock exercise at Bhubaneswar, Odisha and Visakhapatnam, Andhra Pradesh.

d) INCOIS-MEA-NDMA Training Programme for Pacific Island Countries

In collaboration with NDMA and Ministry of External Affairs (MEA), INCOIS has organised a training programme for the officials of Pacific Island countries at INCOIS during 20-25 November 2017. The theme of the training programme was "Early Warning System for oceanic disaster and mitigation with special emphasis on tsunamis". Twenty participants from the Republic of Marshall Islands, Palau, Solomon Islands, Samoa, Nauru, Niue, Vanuatu, Kiribati, Fiji, Cook Islands and Tonga attended the training. Participants witnessed the tsunami mock drill at Bhubaneswar, Odisha and Visakhapatnam, Andhra Pradesh on 24 November 2017.

Participants from Pacific Islands countries attended the INCOIS-MEA-NDMA training programme.

4.4.5. Multi-hazard Vulnerability Mapping

INCOIS has completed the preparation of Multi-Hazard Maps pertaining to Indian mainland. Information from these maps are linked to the real-time Tsunami and storm surge inundation models so that the mitigation of coastal disasters will be more efficient. INCOIS has also developed an integrated 3D visualization and analysis software for the effective usage of the data for disaster management. 3D GIS mapping of selected coastal regions Cuddalore, Puducherry, Machilipatnam, Rameshwaram, Kakinada, Puri, Tuticorin, Nizampatnam, Kochi and Alleppey

Visualisation of 3D GIS data pertaining to selected vulnerable areas

covering 4683 sq. km has been completed. All data are being integrated in 3D/2D visualization and Analysis Software (3DVAS) for operational use.

4.5 Ocean Data Services

Being designated as the National Oceanographic Data Centre (NODC) for India by the International Oceanographic Data Exchange (IODE) programme of the Intergovernmental Oceanographic

Commission (IOC), INCOIS continued to serve as the central repository of several oceanographic data. The data centre sustained and strengthened real-time data reception, processing and quality control of surface meteorological and oceanographic data from a wide variety of ocean observing systems. Surface met-ocean data from various platforms were disseminated to various operational agencies in the country in near-real time. The NODC also provided customized data and products to researchers on request. The list of data added to the archival is given in the below Table.

Insitu and Remote Sensing data setups updated/archived

Table: Details of in situ data received during the reporting period

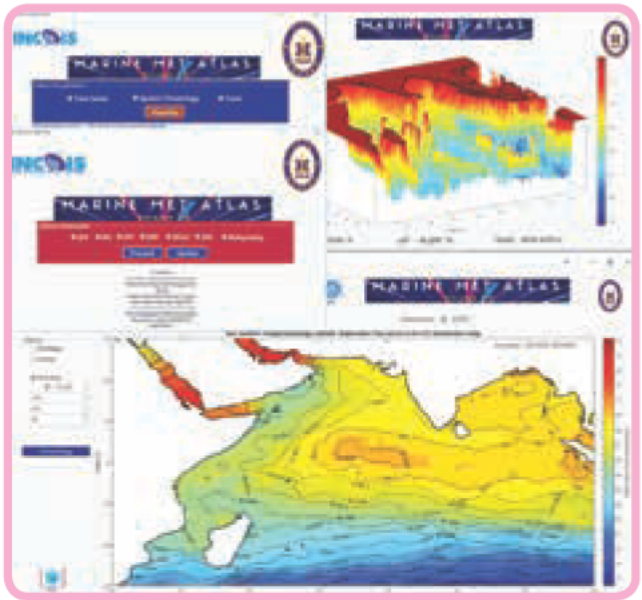
Institute/ Programme	Parameters	Period of Observation	No. of Platforms/ Stations Reported	Status
NIO (XBT, XCTD, SSS)	XBT Profiles XCTD Profiles	Apr 2017 - Mar 2018 Apr 2017 - Mar 2018	44 profiles 55 profiles	Added to the database
NODPAC (Met Observations along Ship track)	Surface met parameters	Apr 2017 - Mar 2017	04 quarterly data	Archived
NODPAC (Met Observations along Ship track)	Surface met parameters, XBT, CTD	1971 - 2017	–	Archived
NIOT - NDBP (Moored buoys)	Met-ocean parameters	Apr 2017 - Mar 2018	19 buoys	Added to the database
NIO (Drifting buoys)	Met-ocean parameters	Apr 2017 - Mar 2018	27 buoys	Added to the database
NIO (ADCP)	Ocean currents	2011 - 2015	–	Archived
PMEL (RAMA buoys)	Met-ocean parameters	Apr 2017 - Mar 2018	16 buoys	Added to the database
INCOIS (Ship-mounted AWS)	Met parameters	Apr 2017 - Mar 2018	33 stations	Added to the database
INCOIS-NIO-NIOT (Coastal AWS)	Met parameters	Apr 2017 - Mar 2018	13 stations	Added to the database
INCOIS (Wave rider buoys)	Wave parameters	Apr 2017 - Mar 2018	16 stations	Added to the database
NIOT (HF RADAR)	Currents	Apr 2017 - Mar 2018	05 pairs of stations	Updated in the database
Argo CTD (INCOIS)	Temperature and Salinity	Apr 2017 - Mar 2018	35079 profiles	Added to the database
ICMAM (COMAPS)	Bio-Geo-Chem-Phy parameters	2011 - 2015	12 stations	Added to the database

Table: Details of remote sensing data holdings

S.no	Sensor/Satellite	Data products	Period of availability
1	OCM-2/Oceansat-2	• Radiance bands • Chlorophyll-a • Kd_490 • TSM • AOD	Feb 2011 to till Date
2	AVHRR, ATOVS / (Metop-1, 2 & NOAA-18, 19)	• Radiance bands • Brightness temp's • Cloud top temp's • SST • FOG • NDVI • Temp, humidity profiles	Aug 2005 to till date (with few data gaps)
3	VIIRS (Suomi-NPP)	• Ocean Color (chl_a, chl_ocx, Kd_490, par, pic, poc) • SST (Split Window, Triple Window) • Other (Fire Points, FOG, NDVI, Cloud products etc..)	May 2016 to till date
4	MODIS/TERRA & AQUA	Ocean, Land & Atmospheric products	Near real time, till date

4.5.1. Marine Meteorological Atlas (MaMeAT)

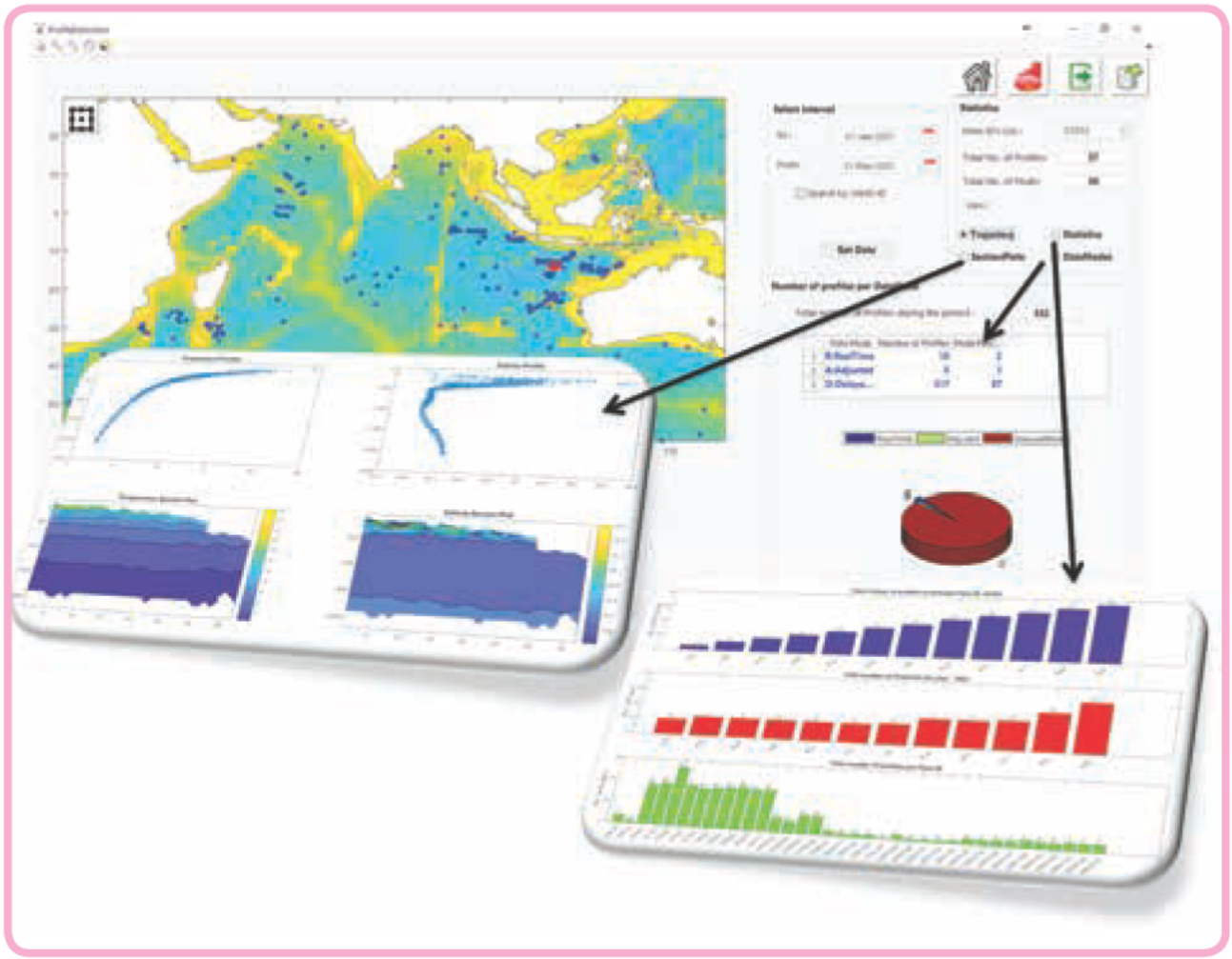
Prepared a Marine Meteorological Atlas, that includes the unique records of marine meteorological data collected by India Meteorological Department, NODPAC and the individual data records obtained from ICOADS. These data sets were processed, quality controlled and merged to form a unique data set for enhancing the marine met climatology of Indian Ocean. The IMD and NODPAC data were compared with the data records from ICOADS and duplications were eliminated. Analysis showed that around 12% data records used in this enhanced climatology are unique compared to the data used to prepare ICOADS climatology. With this base data, a Graphic User Interface (GUI) tool was also built for visualizing the data on different parameters such as SST, SLP, Wind, Relative Humidity, SSS and bathymetry. This tool has capability to generate climatology dynamically based on the chosen period by the user apart from visualizing various plots which are useful for the application of Indian Navy while at sea. Provision to add new marine met data also has been provided in the visualization software.



Snapshots from MaMeAt tool

4.5.2. ARGO Data Extraction tool

INCOIS data centre developed an interactive MATLAB based tool to prepare ARGO database by extracting profiles from individual NetCDF files and for performing analysis and for on-the fly visualization.



Snapshots of ARGO data extraction tool

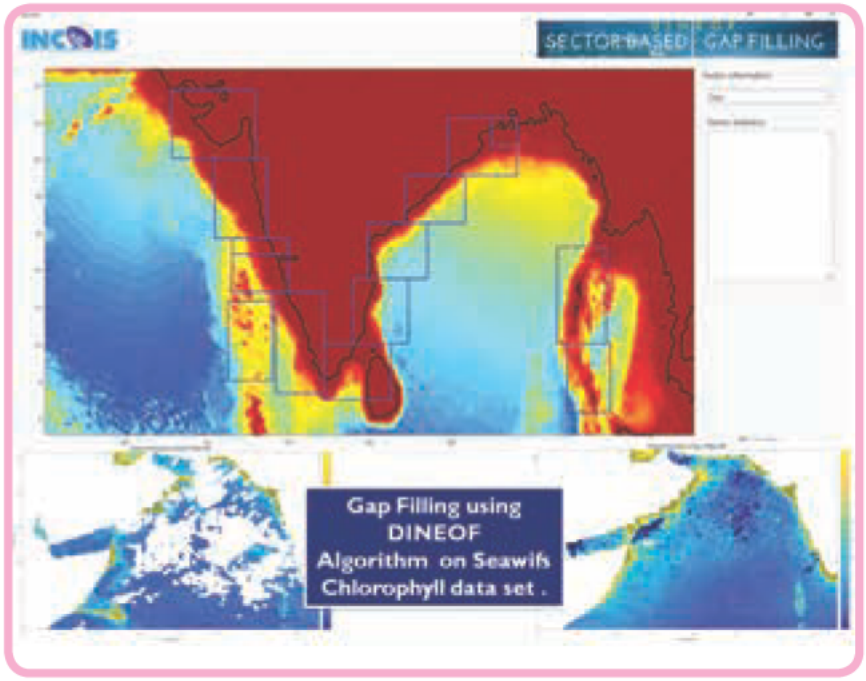
4.5.3. Oxygen data correction using Neural Networks

Sensors used in Argo floats to measure physical and bio-geo-chemical parameters that are sensitive to bio-fouling and can cause the degradation of data. An Artificial Neural Network based method was developed to detect the degradation of sensors and to apply the necessary corrections to the data. The oxygen profiles taken from the World Ocean Data (WOD) were used to train the neural network algorithm. This methodology was extended for the correction of biases in the oxygen data measured by Argo floats.

Correction of degraded oxygen (μ mole $^{l-1}$) values using Neural Networks

4.5.4. Sector based gap filling of chlorophyll data using DINEOF algorithm

Chlorophyll data is extensively used for the generation of PFZ advisories at INCOIS. However, quite often, chlorophyll data from the satellite sensors are contaminated due to cloud cover. In order to have a no-gap dataset of chlorophyll for operational use, a stand-alone application for sector-based reconstruction of cloud mask or data gaps was developed. This tool is based on the gap filling algorithm, Data Interpolation Empirical Orthogonal Functions (DINEOF), which is an EOF based technique developed to reconstruct the missing data in geophysical datasets.



Sample maps of Chlorophyll data before and after gap filling

4.5.5. Metadata portal

A metadata portal for easy and efficient search and discovery of various geospatial datasets collected and maintained under different MoES programmes was developed earlier by the INCOIS data centre. The Metadata portal includes a metadata editor based on ISO-19115 standards relevant to basic geographic information and extensions for imagery and gridded data. A search interface, based on the standard GCMD Science keywords directory, was also developed to search relevant datasets using simple keywords. Metadata from the INCOIS projects and programmes, including Coastal HF Radars (5), Coastal Wave Rider Buoys (19), Coastal Automatic Weather Stations (23)

Snapshots of Metadata portal

and Tide Gauges (35) were uploaded on the portal. Incorporation of metadata of programmes/ projects of other MoES organizations and institutes into the portal is now progressing. A new user interface using responsive web design was developed and a user guide for the easy use of portal was also prepared.

4.5.6. Other significant activities

Data Archival: INCOIS data centre has made significant progress in rescuing historical Met-Ocean data sets. In this project, several valuable historical datasets available in the physical forms such as cruise reports or handwritten notes are being digitized and archived. Digitization of physical records of historical cruises from FORV Sagar Sampada is in progress.

4.6. Computational Facilities, Communications Network and Web Based Services

4.6.1. Computing Infrastructure:

Ever since its establishment as a National hub for Ocean Information services, INCOIS has been on the forefront of establishing, developing, augmenting and upkeep of a host of state-of-the-art computational and communication facilities to cater to the needs of the ocean scientific community. The overarching goal of this programme is to design, develop, implement and to maintain suitable computing (Hardware, Software and Networking), Web and Communication

infrastructure to meet the deliverables as set out in the Mission Mandate of INCOIS. INCOIS hosts state-of-the-art computational facilities that include a high performance computer and its allied infrastructure, 300 TB storage, ERP servers, FTP server, web and application servers, Live Access Server, workstations, desktops, laptops, link load balancers, application load balancers, firewalls, core switches, edge switches and a 30 km long campus-wide networking. The network and the infrastructure are set up in such a manner that no single point of failure can affect the operational services. As on date, INCOIS continues to maintain a computing and network infrastructure with an up-time of 99% to support the operational and R & D projects. Office automation has been successfully implemented over SAP. An HPC with 33 TF compute power was commissioned at INCOIS for its operational R & D activities. Implementation of Digital Ocean and Integrated dissemination system projects is in progress.

4.6.2 Web Based Services

Web Based Services have always remained one of the core areas of strength of INCOIS. The website services have over the years matured as a prime vehicle for providing ocean data, information and advisory services such as potential fishing zone, ocean state forecast, Indian Argo, Indian Ocean Global Ocean Observing System, etc. to all stakeholders and the global community. The web based online delivery system facilitates the user with multi-lingual and WebGIS capabilities to query, analyze, visualize and download the ocean data, information and advisory services on different spatial, temporal resolutions and for their regions of interest. Development of various web applications and periodical updates of website are being carried out both in terms of information and facilities, based on feedback from the user community. INCOIS website being the primary medium to disseminate information about the products is designed using responsive layout which enables access through a wider range of web browsers and devices, including mobiles and tablets.

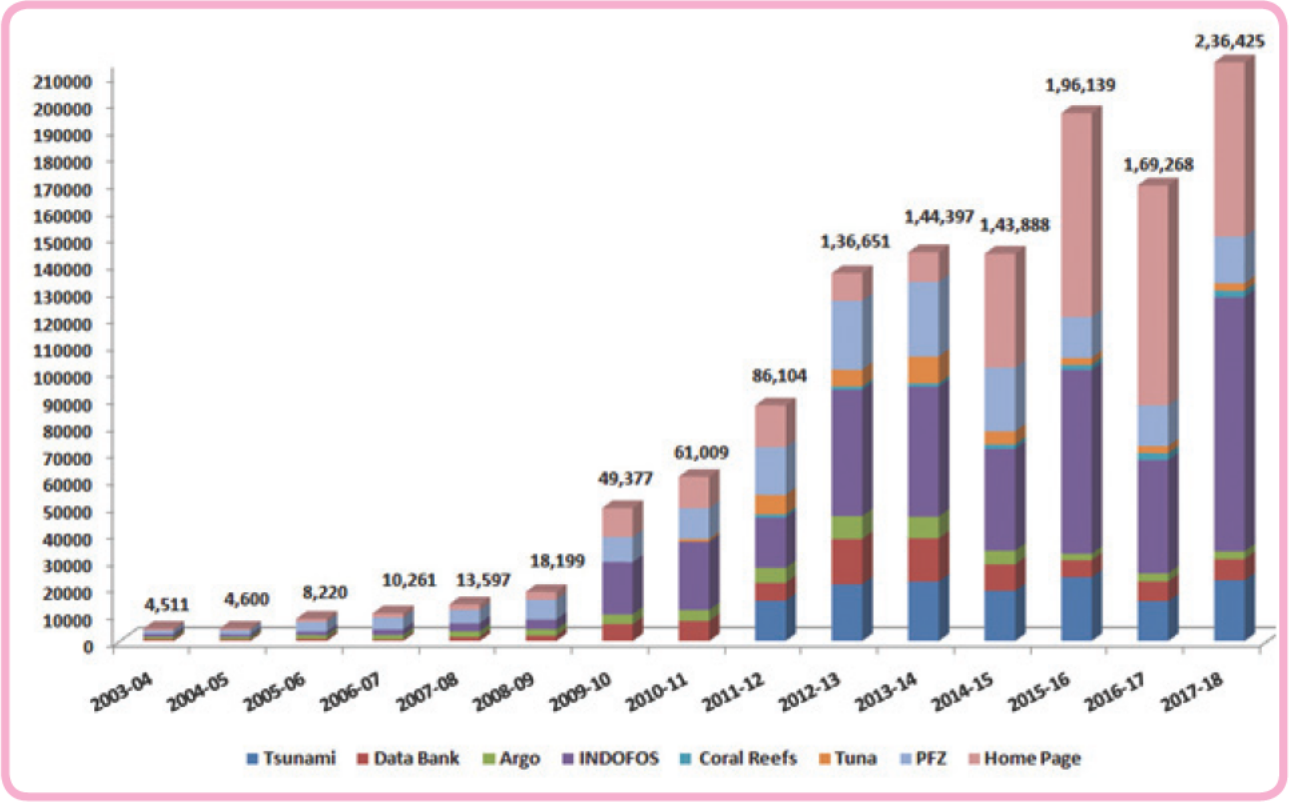
INCOIS provides its ocean information and advisory services through its web portals viz., www.incois.gov.in, www.tsunami.incois.gov.in and www.isgn.gov.in

As in the earlier years, during 2017-18, INCOIS continued to manage the various web services besides developing web applications based on user requirements. Some of the other notable activities during this period were:

- Online Recruitment Portal for various posts at INCOIS, MoES, CMLRE, NCAOR & NCESS.
- Online Project Proposal Submission & Reviewer's Evaluation Application towards Call for Project Proposals Under INCOIS Projects viz., Ocean- Modelling, Data Assimilation and Process Specific Observations (O-MASCOT), Ocean State Forecast (OSF) and Marine Fishery Advisory Services (MFAS)".
- Login based web application for Ocean State Forecast for neighbouring countries Comoros, Mozambique and Madagascar.
- Login-based One Time Registration (OTR) ITCOocean Online Application for the participants to apply for the Training Courses.
- Streamlined the In-house INCOIS Intranet Application.
- Enhanced and streamlined the multilingual web application for Marine Fishery Forecast System.

- Enhanced and restructured various websites viz., Knowledge Resource Centre (KRC), IOGOOS, SIBER.
- Website for "Swachh Bharat", "Swachhta Hi Seva" activities of INCOIS.

Websites developed and maintained by INCOIS for dissemination of information and services



Growth in the number of visitors to INCOIS Website

Web Services for IIOE-2

One of the most important contributions of INCOIS Web Services during 2017-18 was the development of a web portal for the activities pertaining to the International Indian Ocean Expedition-2 (IIOE-2), a global initiative co-sponsored by the IOC, IOGOOS and SCOR, with INCOIS as a major partner. The web-based application (www.iioe-2.incois.gov.in) developed by INCOIS for IIOE-2 provides a user-friendly environment for the presentation of various activities under IIOE-2 and their progress. In addition, the web-based services help in managing the IIOE-2 community database and the dissemination of IIOE-2 Monthly Newsletter. The responsive layout of the website makes it accessible through a wide range of web browsers and devices, including mobiles and tablets. All activities related to the updation and management of web portal are being handled on a daily basis by INCOIS which also hosts the Joint Project Office of IIOE-2.

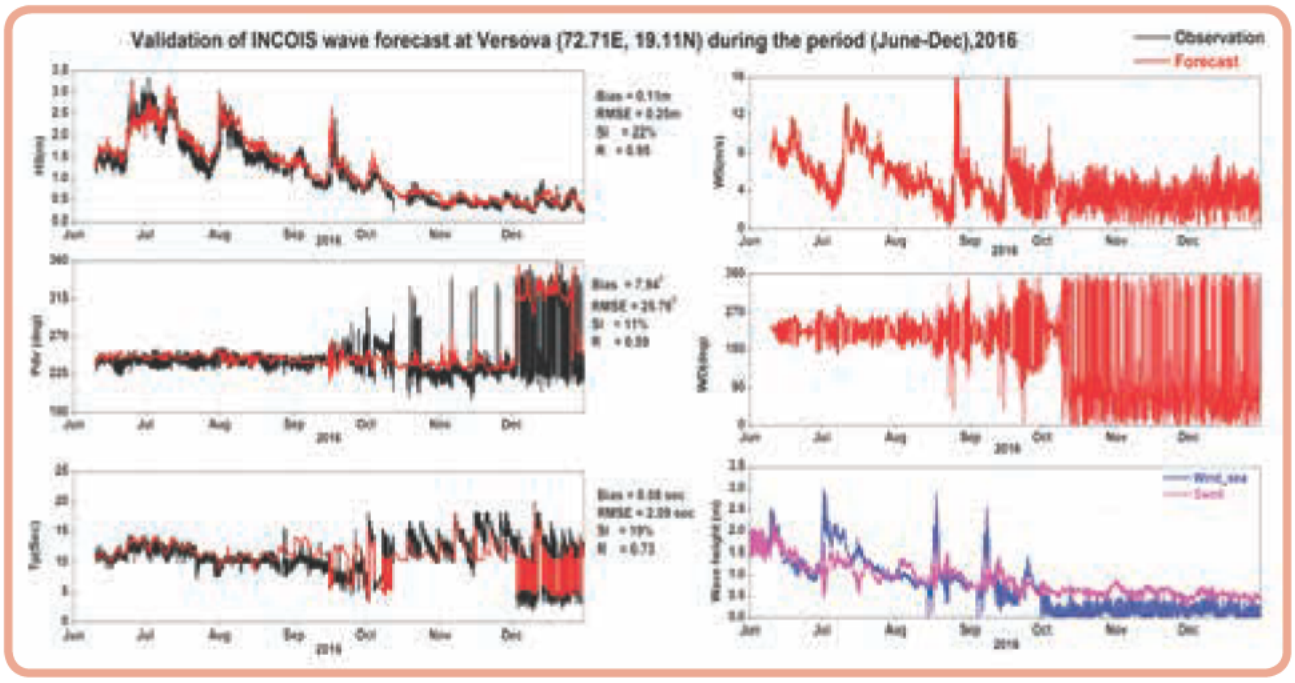
IIOE-2 Webpage (left), metadata portal (right top) and tracks of completed and proposed IIOE-2 endorsed cruises (right bottom).

5. Consultancy projects

INCOIS continued to support the requirements of the maritime and offshore industry by providing consultancy services on specific and customised information and forecasts on ocean state parameters like winds, waves (both wind waves and swells, currents and tides). Details of the consultancy projects are given below.

5.1. Ocean state parameters for Jawaharlal Nehru Port Trust

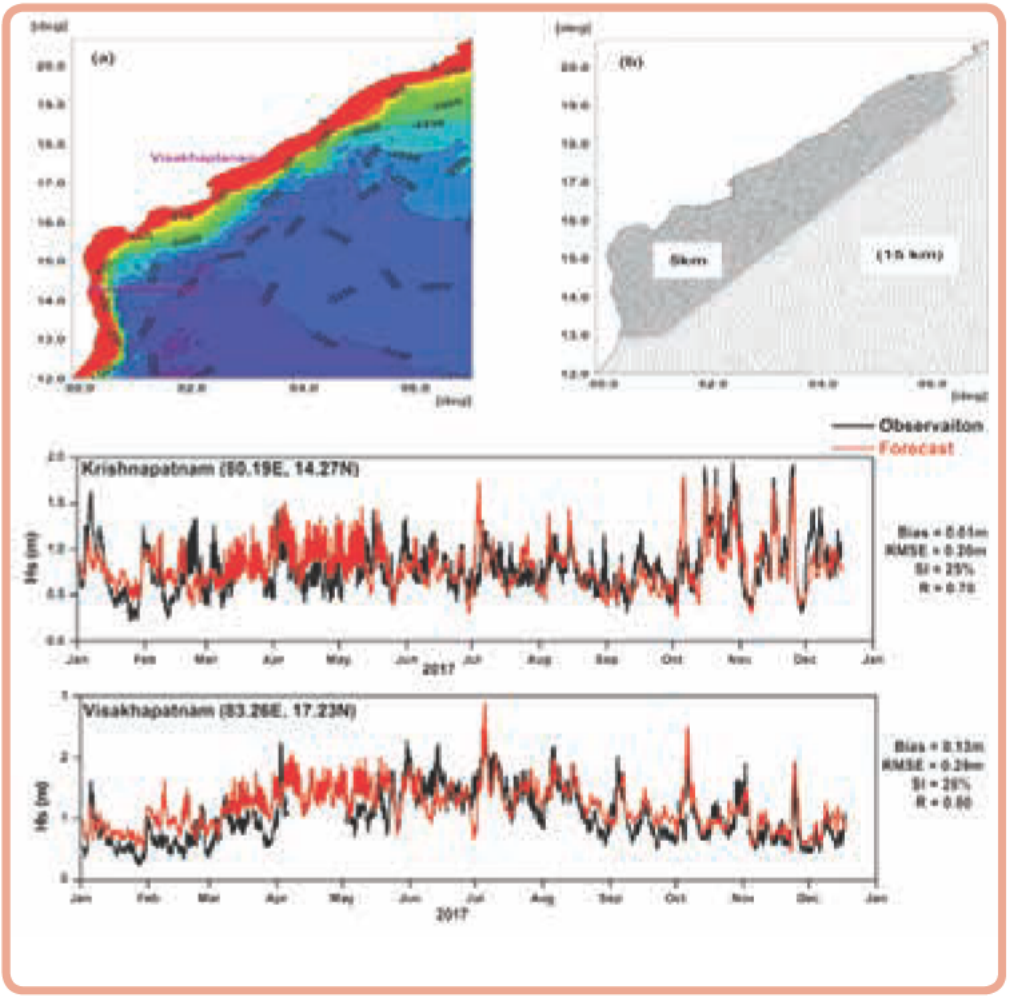
Jawaharlal Nehru Port Trust (JNPT) required wave parameters such as significant wave height (Hs), peak wave period (Tp), peak wave direction (Pdir) for the period 1 January 2016 to 31 December 2016 at a specific location for their operations. INCOIS prepared the necessary information using a suit of wave models, validated the simulations using the data from wave rider buoy located off the coast of Versova and provided to JNPT. Total revenue earned by INCOIS from this project was Rs. 12.63. Lakhs.



Wave parameters simulated by the numerical model setup for JNPT port area is validated against the observations.

5.2. Inland Vessel (IV) rules for State of Andhra Pradesh

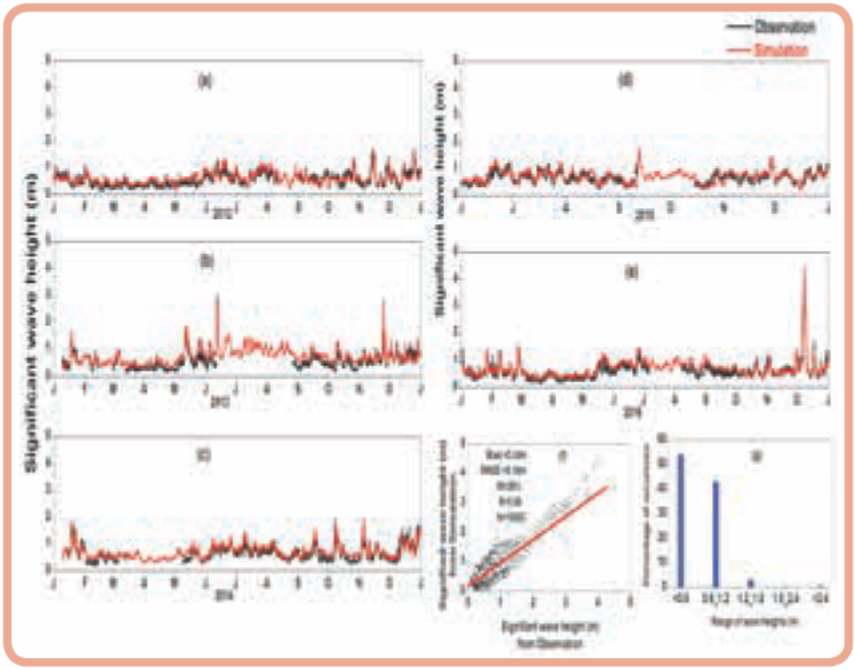
Andhra Pradesh Port Management Board (APPMB) required to identify wave pattern zones to regulate the Inland Vessel rules for the Andhra coast. INCOIS catered to this requirement based on the simulations of wave parameters for the period January 2011 to December 2017 using a suite of wave models and comparing the simulations with the observations from wave rider buoys deployed at Krishnapatanam and Visakapatanam. The requirement of APPMB for the dynamic IV information on an operational basis from July 2018 for a period of one year will be provided by INCOIS as part of this project. The revenue earned by INCOIS from this project was Rs. 11.80 Lakhs.



Bathymetry(top left panel) and model configuration (top right panel) used for generating the IV information for the Andhra coast and validation of model simulated waves using observation (bottom panels).

5.3. Inland Vessel rules for Andaman and Nicobar Islands

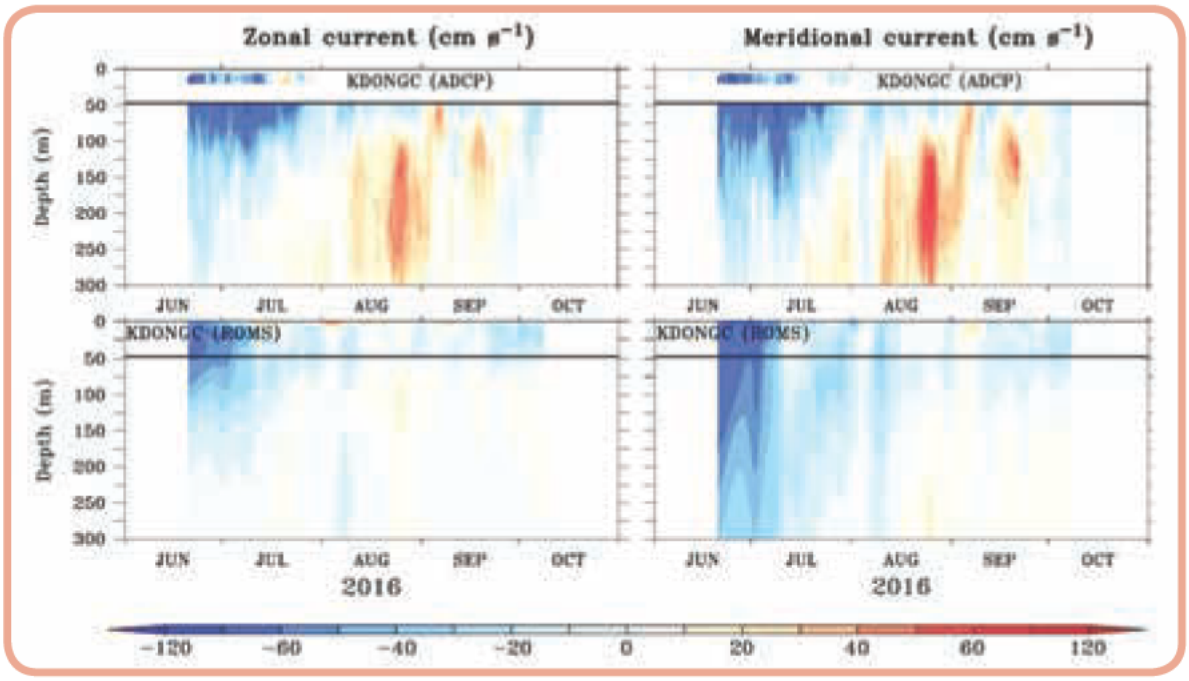
Port management authority of Andaman and Nicobar Islands requested INCOIS to provide seasonal images of inland vessel limits and its daily variation of IVL for the Andaman and Car Nicobar Islands. INCOIS provided the images of seasonal patterns of IVL in the necessary format based on the simulations of wave parameters using a suite of numerical models. INCOIS also provides daily images of IVL to the port management authority on an operational basis. INCOIS earned Rs. 27.07 Lakhs by providing this consultancy service.



Comparison of model simulated wave height with observation at Port Blair (a-e), scatter plot for the comparison (f), and percentage occurrence of various ranges of wave heights.

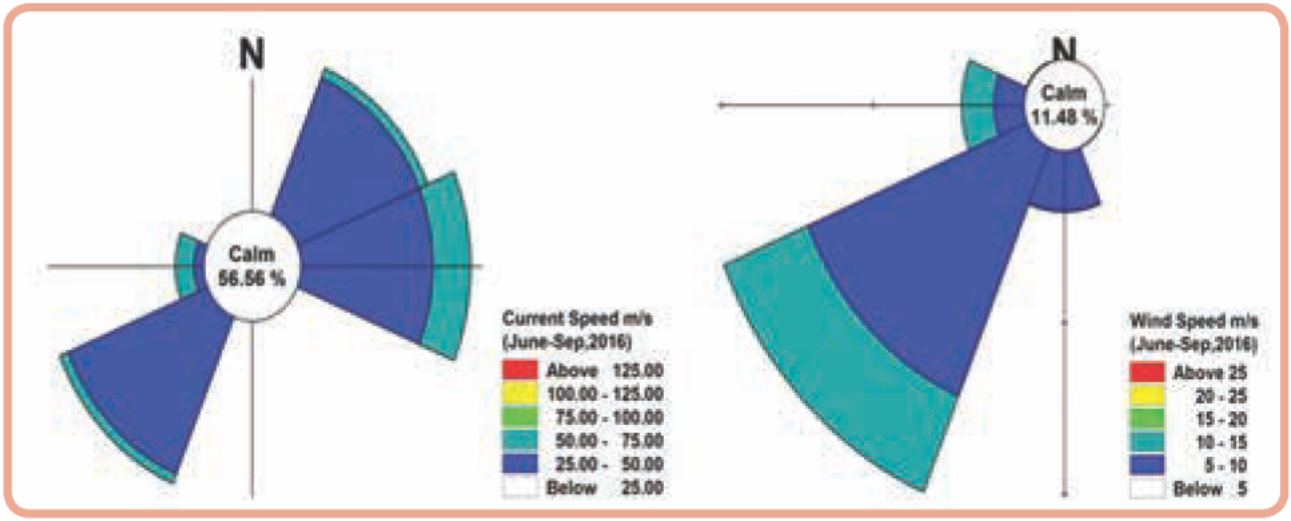
5.4. Consultancy service to Oil and Natural Gas Corporation

Oil and Natural Gas Corporation (ONGC) requested information and forecasts on extreme wind speeds, wave heights and peak periods for the return periods of 1, 10 and 100 years and the statistics such as variation of wave height vs. wave period (Hs/Tp) for their central process platform at ONGC KG DWN 98/2 site off Kakinada. INCOIS executed the project successfully and provided adetailed report along with the validation of the simulated inter-annual winds and wave parameters during the occurrence of cyclones and fair-weather seasons using in situ and satellite data and surface and subsurface currents using the data provided by ONGC. Rs. 23.53 Lakhs was earned by INCOIS through this service.



Zonal current (left panels) and meridional current (right panels) from observation (top panel) and the model (bottom panel) at Kakinada.

ONGC awarded another consultancy project worth Rs. 102 Lakhs to INCOIS in January 2018 to provide forecasts of currents with 6-day lead time during the field development of at their site, EOA KG-DWN-98/2 (off Kakinada, Andhra Pradesh) and to provide hindcasts for three years. The duration of the project is three years.



Rose Diagram showing the currents (left panel) and wind speed (right panel) with their directional dominance at a location in the ONGC field off Kakinada.

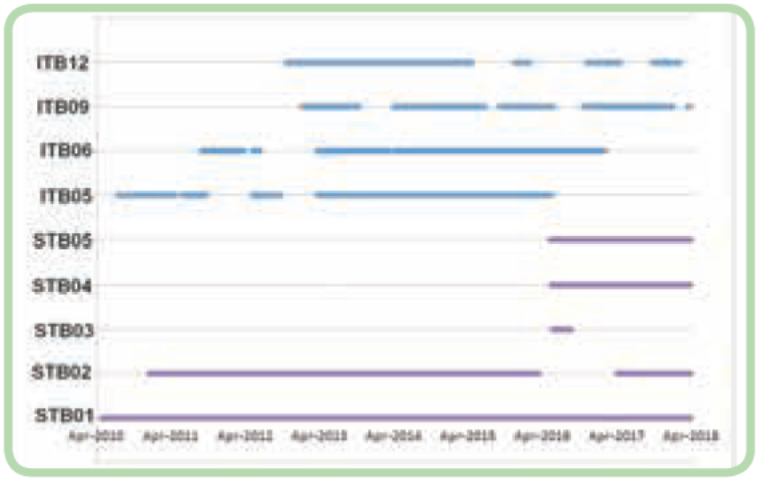
6. Ocean Observation Network

Sustained Ocean observation is an integral part of operational oceanography as the real-time data from these platforms provide necessary information for ascertaining the validity of advisories/ forecasts as well as the data for assimilation in the numerical models used for predictions. Data from the ocean observation platforms as well as research cruises also provide opportunities to study the specific processes that influence the variability of oceans. In order to provide the best operational oceanographic services, INCOIS maintains large networks of ocean observation systems.

6.1. Tsunami Buoys

INCOIS continued to maintain a network of 4 tsunami buoys deployed close to the tsunamigenic source regions in the Bay of Bengal and Arabian Sea. In addition to that, INCOIS also received real-time data from two tsunami buoys deployed and maintained by National Institute of Ocean Technology (NIOT, Chennai). These buoys are capable of detecting very minor changes in the water level, of the order of 1 cm, at water depths up to 6 km. The data from these buoys were transmitted in real time to the Indian Tsunami Early Warning Centre (ITEWC) at INCOIS through satellite communication. Apart from these buoys, real-time data from around 50 tsunami buoys operated by other

Locations of the Sea level network of Tsunami buoys



Data availability of tsunami buoys from April 2010 - March 2018 (Purple: INCOIS STBs; Blue: NIOT tsunami buoys)

STB02 Servicing cruises during March-April, 2017

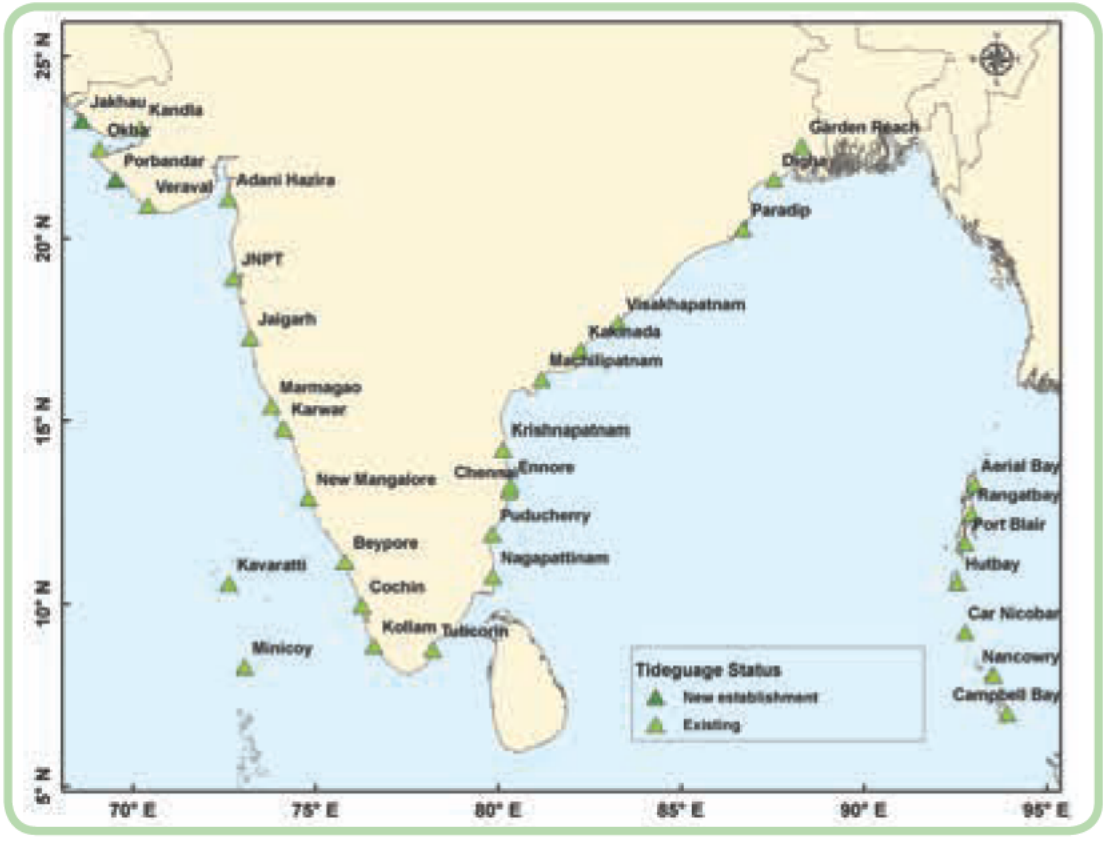
countries in the Indian and Pacific Oceans were also received at ITEWC and the data are made available on the tsunami website. INCOIS also shared the real time data from the tsunami buoys to NDBC-NOAA for the benefit of global users. As part of the annual maintenance, STB02 system (Arabian Sea) was redeployed during a cruise on board Sagar Nidhi during March-April, 2017.

6.2. Tide gauges

In the FY 2017-18, INCOIS set up 2 new Radar-based tide gauges at Porbandar and Jakhau and continued to maintain the 33 tide gauges which were earlier established (in the year 2010, 2015 & 2016) at strategic locations along the coasts of the Indian mainland and islands to monitor the progress of tsunami waves and to validate the model simulations. Continuous real-time data from tide gauges were received at ITWEC through INSAT and GPRS communications. Maintenance of the tide gauges were carried out in collaboration with Survey of India (SoI), Dehradun. In addition, INCOIS also received data from around 300 international tide gauges in near-real time which are being operated by other countries. INCOIS shared data from 8 tide gauges (Chennai, Kochi, Nancowry, Port Blair, Visakhapatnam, Minicoy, Marmagao and Veraval) in real time to IOC Sea level stations monitoring facility for the benefit of global users.

Table: Locations of new Radar-based tide gauges established by ESSO-INCOIS in 2017-18.

S. No	Station Name	Latitude (°N)	Longitude (°E)	Installed Date
1	Porbandar	21.621	69.522	April 2017
2	Jakhau	23.243	68.606	June 2017



Locations of the Sea level network of Tide Gauges

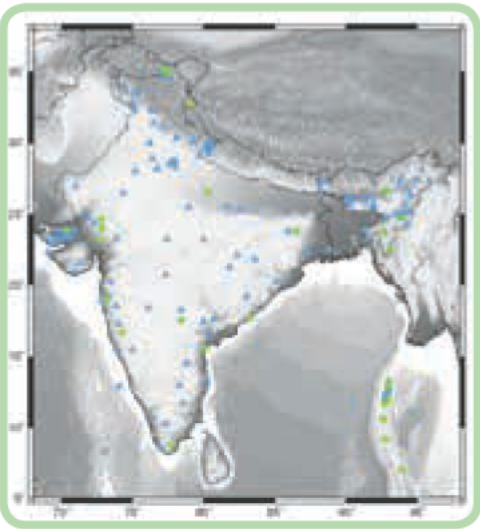
Data availability from the tide gauge network during April 2010-March 2018

New Radar tide gauge station at Porbandar

6.3. Network of communication systems

a) Establishment of GNSS & Strong Motion network in A&N Islands

INCOIS had taken up a project to install co-located Strong Motion sensors, GNSS receivers and Meteorological sensors with real-time VSAT connectivity at 35 locations in the Andaman & Nicobar (A&N) Islands. So far INCOIS received NOC from the concerned authorities to install the GNSS stations at 31 locations. Accordingly, Andaman Public Works Department (APWD) completed constructions of small cabins at 30 locations and construction is progressing at one more location. The installation of GNSS receivers and Strong Motion Accelerometers were completed at 29 locations and installation at remaining locations will be completed by August 2018. For remaining 4 locations, INCOIS has received the in-principle approval (Stage-I) from Department of Environment & Forests, Andaman & Nicobar Islands for the construction of observatories. INCOIS has already competed the Environmental Impact Assessment (EIA) study with the support of Andaman and Nicobar Centre for Ocean Science and Technology (ANCOST), Port Blair and submitted a report to Department of Environment & Forest for obtaining the Stage-II approval for the constructions in those locations. The integration of VSAT units to establish connectivity for receiving the data in real-time from GNSS is progressing.



Seismic network in India

b) Establishment of Indian Seismic and GNSS Network (ISGN)

A real-time network of seismic and GNSS stations was established by connecting local networks operated by regional institutes as well as standalone stations sanctioned under various projects to individual Principle Investigators by MoES. Currently data from 130 stations are being received at INCOIS, Hyderabad and National Centre for Seismology (NCS), New Delhi which are acting as the Central Receiving Stations (CRSs). The seismic as well as GNSS near real-time data are available through the website https://www.isgn.gov.in. Data from selected stations are available to all users for operational use. One hundred and twenty-two

Seismic observatory at Siachen

(122) users have registered at ISGN web portal. The historical data collected from NCESS and a few other regional centres have been archived. A data calendar on availability of the data for the benefit of users has been prepared. The historical data available with NCS are being currently converted into common format to archive that at ISGN data centres. The project is transferred to National Centre for Seismology (NCS) from 1 April 2018.

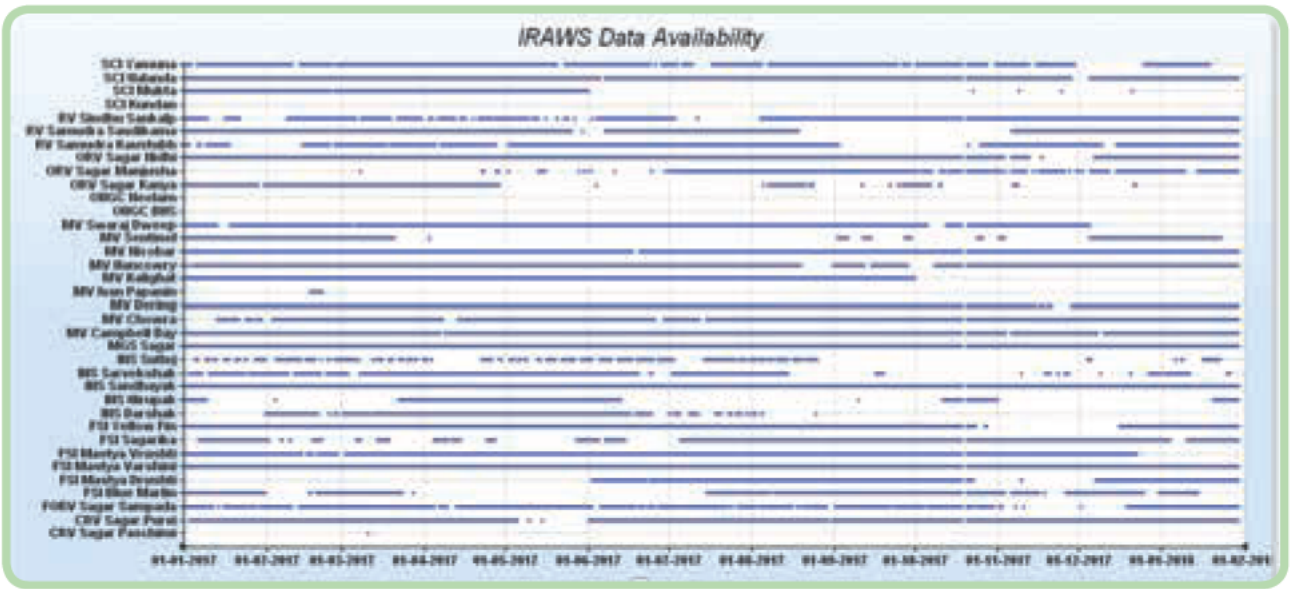
c) Suomi NPP ground station

Suomi NPP ground station

INCOIS established a Suomi NPP ground station to acquire real-time data from VIIRS sensor and generate products of Sea Surface temperature (SST), Chlorophyll-a and Attenuation coefficient Kd490 for operational generation of IPFZ (Integrated potential fishing zone) advisory services.

6.4. Automated Weather Stations (AWS)

ESSO-INCOIS maintained a network of 34 AWS on board vessels owned by different government agencies such as MoES, SCI, FSI, NHO and GSI. In the FY 2017-18, INCOIS carried out 132 preventive maintenances, 40 breakdown maintenances and calibrations of AWS sensors (Wind Sensors– 8, Barometric Pressure-8, AT/RH Sensors-11, Long Wave Radiation Sensors-20, Short Wave Radiation Sensors-21, Rain Gauge Sensors-28) to ensure continuous availability of quality data.



Data availability chart for the AWS installed and maintained by INCOIS

6.5. Wave Rider Buoy Network

ESSO-INCOIS maintained a network of 16 wave rider buoys for monitoring the state of the ocean as well as the online/offline validations of the ocean state forecasts. Regular calibration of the systems at recommended intervals were done to maintain the quality of the data from the buoys. The INSAT tracking mechanism for buoys which was developed indigenously at ESSO-

Locations of wave-rider buoys deployed and maintained by INCOIS.

Data availability chart of the wave rider buoys

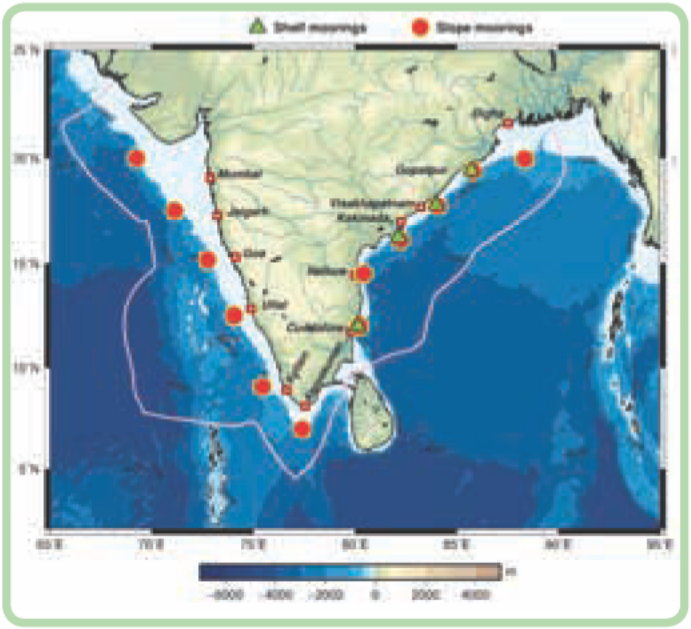
INCOIS helped in successful retrieval of 14 buoys that drifted away from the locations of their initial deployment during the year. These buoys were later redeployed in their respective locations.

6.6. Argo floats

In the last FY, INCOIS deployed 35 Argo floats in the Indian Ocean. These deployments included 25 standard floats (temperature and salinity sensors only), 9 Argo floats equipped with temperature, salinity, chlorophyll, backscattering and dissolved oxygen sensors and one EM Float equipped with temperature, salinity and electromagnetic current measurement sensors. Thus, by March 2018, Indian contribution to this international project has increased to a total of 453 floats, of which 148 are active and transmitting data in near-real time. In addition to these deployments by India, 2746 Argo floats were deployed in the Indian Ocean by other countries (USA, UK, France, Germany, Japan, China, Canada and Australia). Including them, 826 floats are active in the Indian Ocean as on 31 March 2018. In the year 2017-18, INCOIS received 34,701temperature and salinity profiles from Argo floats and the data were quality controlled and archived.

6.7. Coastal ADCPs

During the reporting period, 16 ADCP mooring were maintained along the coast of India. In the east coast, 4 moorings are active in the continental shelf and 6 mooring are active in the continental slope as of March 2018. Out of these 16 moorings, 4 shelf moorings and 1 slope mooring in the east coast and all the 6 slope moorings in the west coast are equipped with sufficient number of ADCPs to measure current profiles for the full depth of water column. Three cruises were conducted during the period April 2017 to March 2018 on board Sindhu Sadhana (SS-42 during 1-29 October 2017; 19 days for mooring maintenance) * and Sindhu Sankalp (SSK-

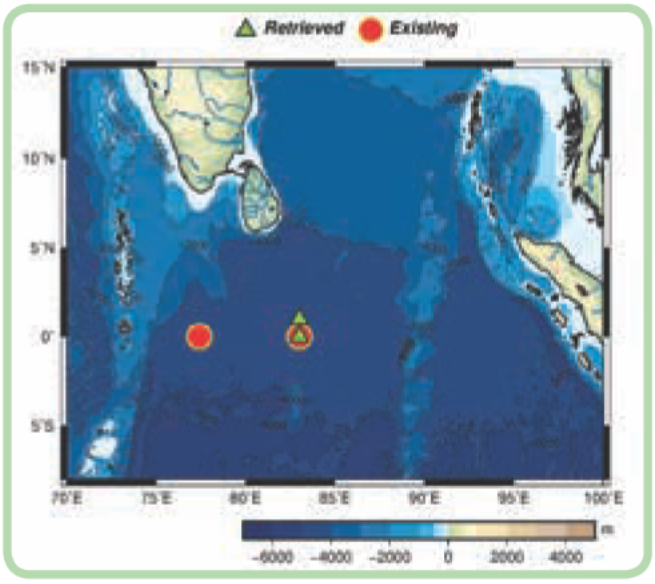


Locations of ADCP moorings; the background shows the bathymetry (m). The Indian EEZ is marked by the pink curve. The present location of the ADCP moorings on the continental slope is shown by the red circles. The green triangles show the location of the shelf moorings; these moorings are now restricted to the east coast and are located off Cuddalore, Kakinada, Visakhapatnam, and Gopalpur.

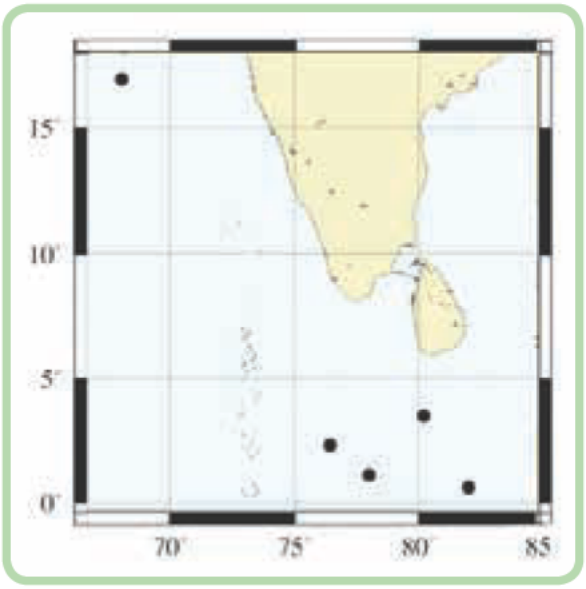
108 during 7-11 November 2017; 5 days for mooring maintenance and SSK-11 during 10-28 April 2018; 19 days for mooring maintenance) to service these mooring networks.

6.8. Equatorial current meter array

During the period April 2017 to March 2018, two (2) current meter mooring were maintained in the equatorial Indian Ocean. During October, 2017 two moorings at 1.5° N and 0° along 83° E were successfully recovered after three years, and two new moorings were deployed along equator at 83.05° E and 72.56° E. The two new moorings are equipped with two 75 kHz ADCPs to measure currents in the top ~900 m and two rotor current meter (RCM) at ~1000 and ~4000 m to measure the single-point currents. One scientific cruise was conducted onboard NIO ship Sindhu Sadhana* during 1- 29 October, 2017, which included the servicing of this mooring.



Status of equatorial current meter array during April 2017 to March 2018. The red circle represents existing mooring and green triangle represents retrieved mooring during October, 2017. The background shows the bathymetry (metres)



Deployment location of Drifters in the Indian Ocean during 1 April, 2017 to 31 March, 2018

6.9. XBT/XCTD/Drifting buoys

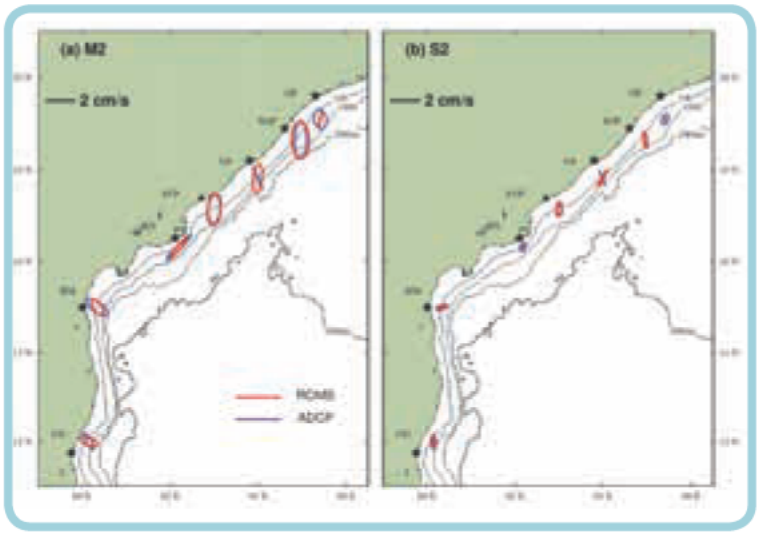
During the period April 2017 to March 2018, 4 transects were conducted (2 along Chennai-port Blair and 2 along Port Blair- Kolkata) to collect 24 XBT's and 12 XCTD's profiles. In addition, 82 water samples also were collected. During the reporting period 5 drifters were deployed. At present 4 drifters are active in the Indian Ocean.

XBT/XCTD transects for the period 1 April 2017 – 31 March 2018 (XBTs are shown in red colour and XCTDs in blue).

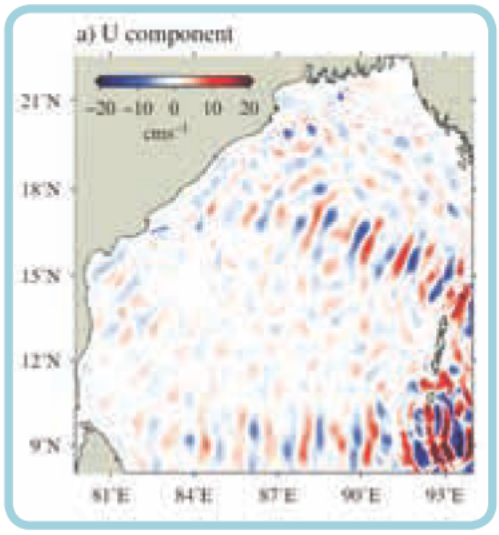
7. Ocean Modeling, Data Assimilation and Process Specific Observations (O-MASCOT)

7.1. Coastal Ocean Modeling using Regional Ocean Modeling System

INCOIS completed setting up of high resolution ROMS, viz. WC-HOOFS (for the west coast of India), SEA-HOOFS (for the southeastern Arabian Sea) and BB-HOOFS (for the Bay of Bengal) as part of the HOOFS project. All these configurations are coupled with accurate tidal forcing, which is one of the most important sources of variability in the coastal circulation. Energetics of internal tides in the coastal regions were studied in detail to identify the sources of IT generations and dissipation regions. It was found that the baroclinic tides are energetic in the southern and northern

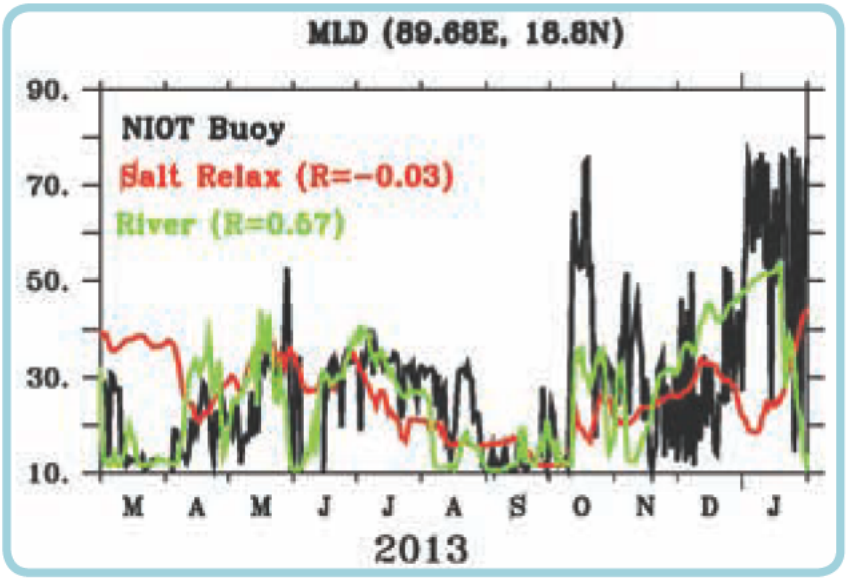


Comparison of M2 and S2 tidal ellipses derived from model simulations and observations using ADCPs along the east coast of India.



Snapshot of 10-14 hour band-passed field of zonal velocity depicting the propagation of internal tides in the Bay of Bengal.

parts of the east coast of India, compared to the central parts. Similarly, it was also observed that the local maxima in baroclinic tidal energy off the coast of Gopalpur peaks during the neap phase of the local tide instead of its spring phase. Detailed investigation showed that the internal tides generated near the Andaman Islands propagate westward in the Bay of Bengal and reach the east coast of India in about 6



Variation in the depth of mixed layer simulated by ROMS with and without river discharge data input are compared with the observation.

days. These remotely forced internal tides were found to be the source of the peak in the baroclinic tidal energy in the east coast.

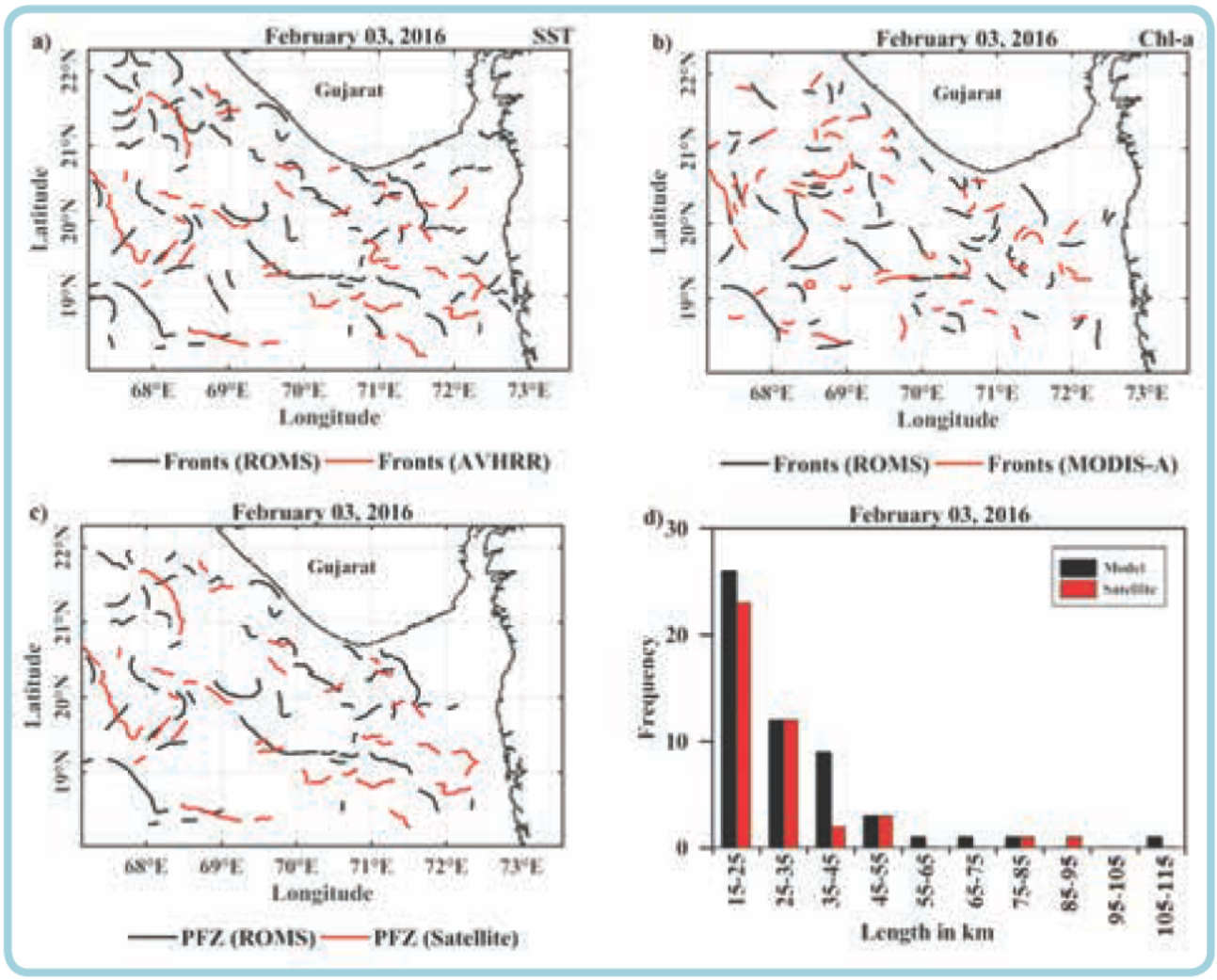
Since the river runoff data were not incorporated in the ROMS configuration which is being used for operational forecasts, the sea surface salinity has been relaxed to monthly climatological fields. This is a limiting factor to carry out processes studies using the model simulations to improve it further. In order to overcome this limitation, monthly climatology of fresh water discharge from seven rivers to the Bay of Bengal (Ganga, Brahmaputra, Irrawaddy, Mahanadi, Godavari, Krishna and Cauvery) are now incorporated in the Indian Ocean configuration of ROMS with 1/12 degree spatial resolution. Analysis of the simulations suggests that the model is stable after incorporating the river discharge data and it also improved the quality of simulations considerably.

7.2. Marine Ecosystem Modelling

Non-availability of satellite measured data on sea surface temperature (SST) and chlorophyll-a (Chl-a) during cloud cover conditions is a serious challenge in the generation of the PFZ advisories issued by INCOIS. Further, the information on key parameters like dissolved oxygen are not available on a regular basis to further improve the accuracies of PFZ services. In order to overcome the operational difficulties of PFZ advisories and graduating PFZ advisories into PFZ forecast as well, a coupled physical-biogeochemical model has been configured using Regional Ocean Modelling system (ROMS) which is capable of simulating the mechanisms controlling ocean biogeochemical tracers, including ocean circulation, carbon cycles, and the marine ecosystem. The validation of the simulations from the coupled model with a wide range of observational data demonstrated that the model has considerable capability in reproducing marine ecosystem dynamics at synoptic and seasonal time-scales in the Indian Ocean.

An automated front detection system has been developed in MATLAB environment, which can be applied directly on NetCDF data available from various satellites as well as from models to identify PFZs. In this front detection system, a user specified criterion has been prescribed to apply Cayula and Cornillon (1992) algorithm on SST data for identifying thermal fronts. The front detection system identifies Chl-a fronts using Canny (1986) edge detection algorithm. The system has been configured in such a way that it will consider both SST and Chl-a fronts into account before generating PFZs. Data on SST/Chl-a derived from satellites as well as the coupled ecosystem model simulations were subjected to the front detection system and it was found that the average length of the PFZ lines derived using satellite data was 28.8 ± 13.2 km and that using model data was 33.3 ± 17.5 km.

In order the understand and assess the impact of climate change in the marine ecosystem of the coastal and open ocean, two regional configurations of biophysical model based on Modular Ocean Model (MOM5.1) with resolution 1/4° degree and 1/20° degree were configured. The biogeochemical module is based on Tracers of Phytoplankton with Allometric Zooplankton (TOPAZv2) and consists of 30 tracers. While the 1/4° model has 40 vertical levels, the 1/20° model has 50 layers with 1-1.5m vertical resolution in top 30 m to capture the biochemical variability over the shelf along the coast of India. A comparison of the model simulations with observed ARGO profile in the Arabian Sea suggested that models can capture the depth of the 23°C isotherm (D23;

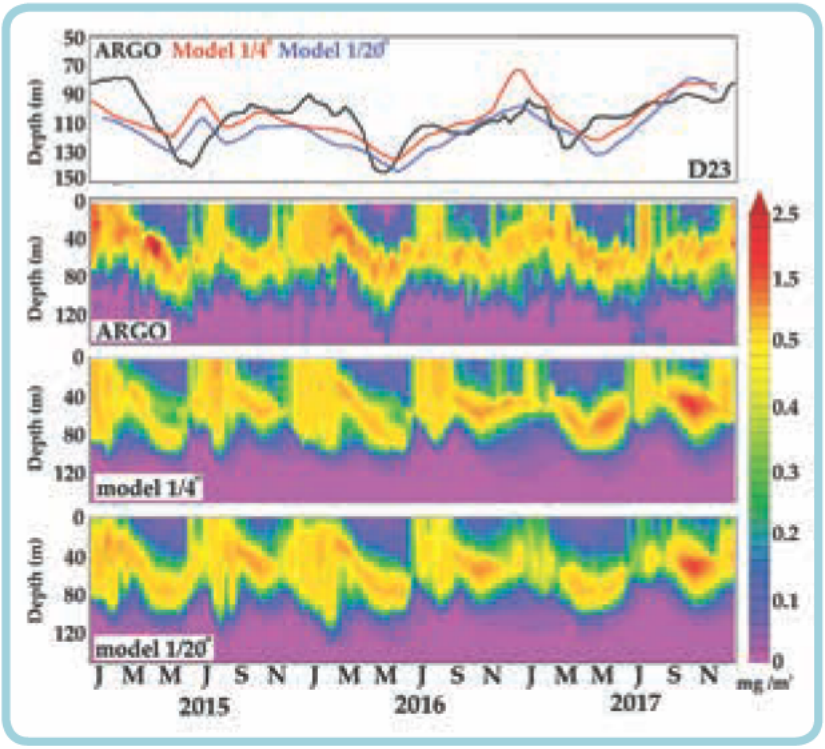


Thermal fronts, Chl-a fronts, PFZs and the frequency distribution of length of PFZ lines derived from satellites and ROMS simulations.

a proxy for the thermocline depth) quite well; with high resolution model perform slightly better than the coarse model. Both models also captured the depth and magnitude of the subsurface chlorophyll maxima and semiannual surface bloom (during summer and winter) throughout the record.

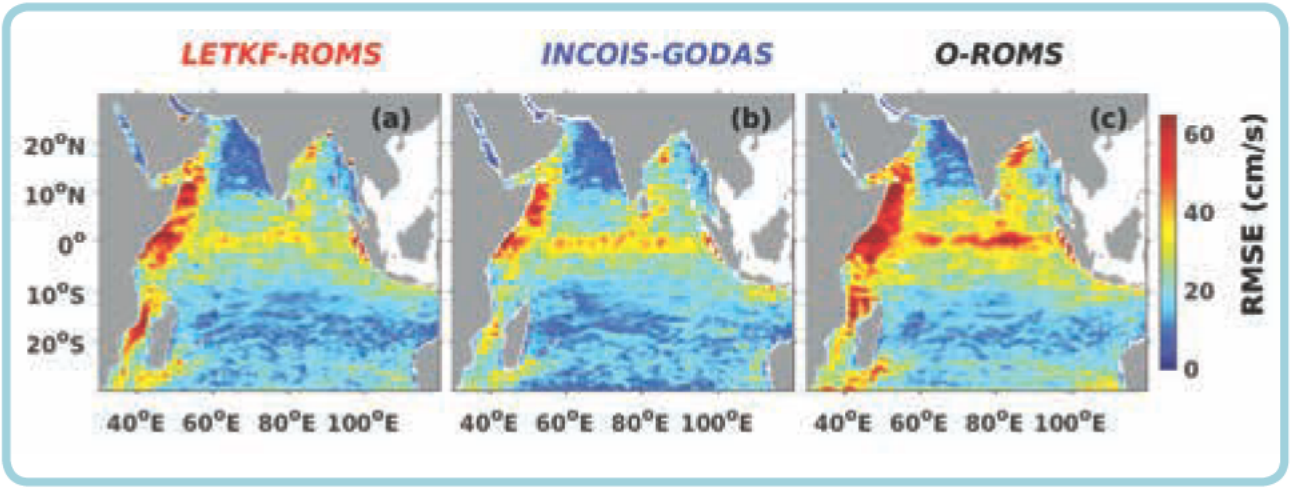
7.3. LETKF-ROMS For Operational Ocean Forecasts

INCOIS has successfully developed an ocean data assimilation system, designed for the operational configuration



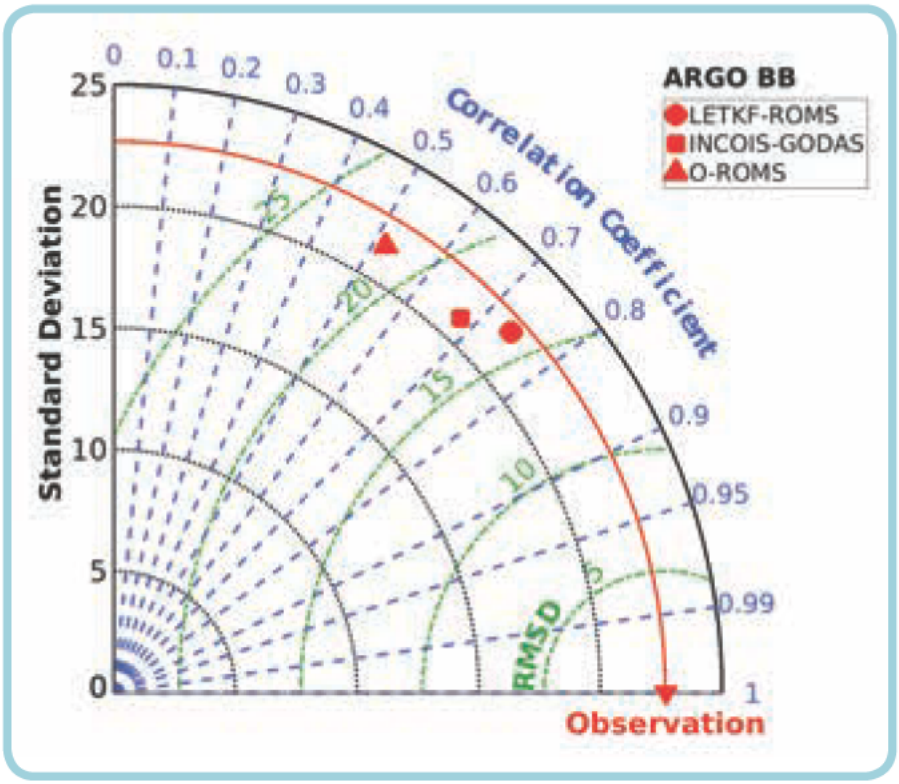
(Top) Comparison of the model simulated D23 with observed D23 from an ARGO float in the central Arabian Sea. The shaded plots show chlorophyll concentration from ARGO and model simulations

of Regional Ocean Modelling System (ROMS) in INCOIS. The newly developed assimilation system, LETKF-ROMS, is based on Local Ensemble Transform Kalman Filter (LETKF). LETKF is



RMSE of zonal current with respect to OSCAR

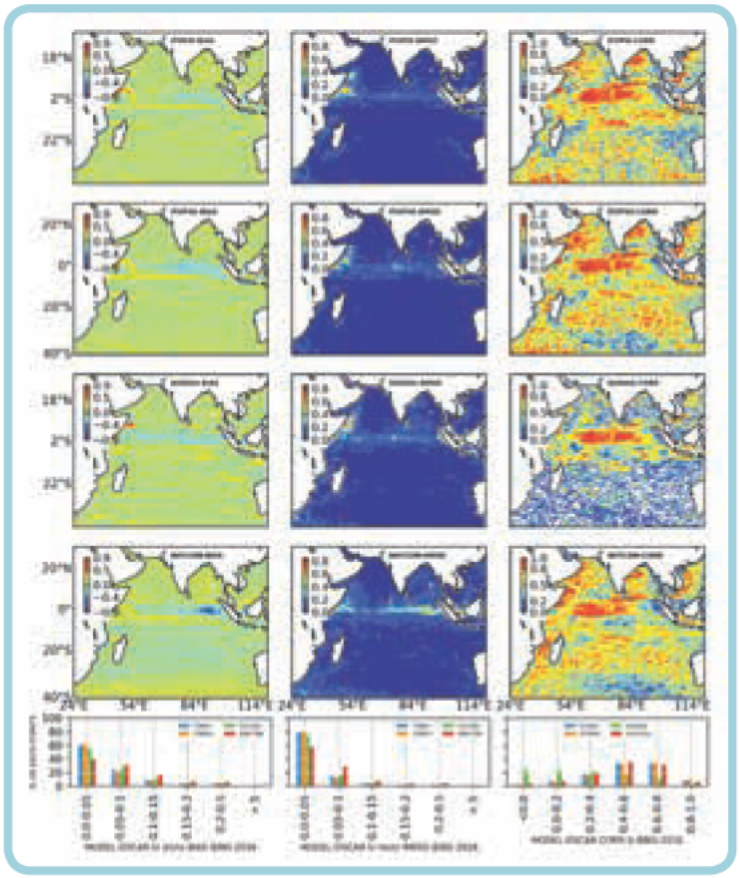
a state-of-the-art data assimilation technique, which can be used to prepare accurate ocean analysis. LETKF-ROMS in INCOIS assimilates in situ temperature and salinity and satellite track data of sea surface temperature. The system also has the ability to assimilate satellite track data of sea level anomaly and sea-surface salinity. An unconventional approach was used to generate the initial ensemble that relied on using two different vertical mixing schemes and a range of model coefficients like trace diffusivity coefficients and viscosity coefficients spread across the ensemble members. It has been devised to arrest the collapse of the ensemble spread (or filter divergence) in the assimilation system. Another unique feature of this LETKF-ROMS is an introduction of a scheme to prescribe flow dependent observation error covariance. It ensures that the spatio-temporal variability observed in the representation errors (RE) in observations is also fed into the assimilation system. Several experiments were carried out to determine optimal configurations of the system such as data assimilation frequency, localization radius and covariance inflation parameters. Validation of the ocean analysis based on the LETKF-ROMS with available observations shows that the LETKF-ROMS system has a very good skill in reproducing the observed circulation and thermohaline structure of the ocean.



Taylor diagram depicting the statistical validation of D20 derived from LETKF-ROMS and INCOIS-GODAS w.r.t. Argo floats in Bay of Bengal

7.4. Ocean Forecasting System based on HYCOM

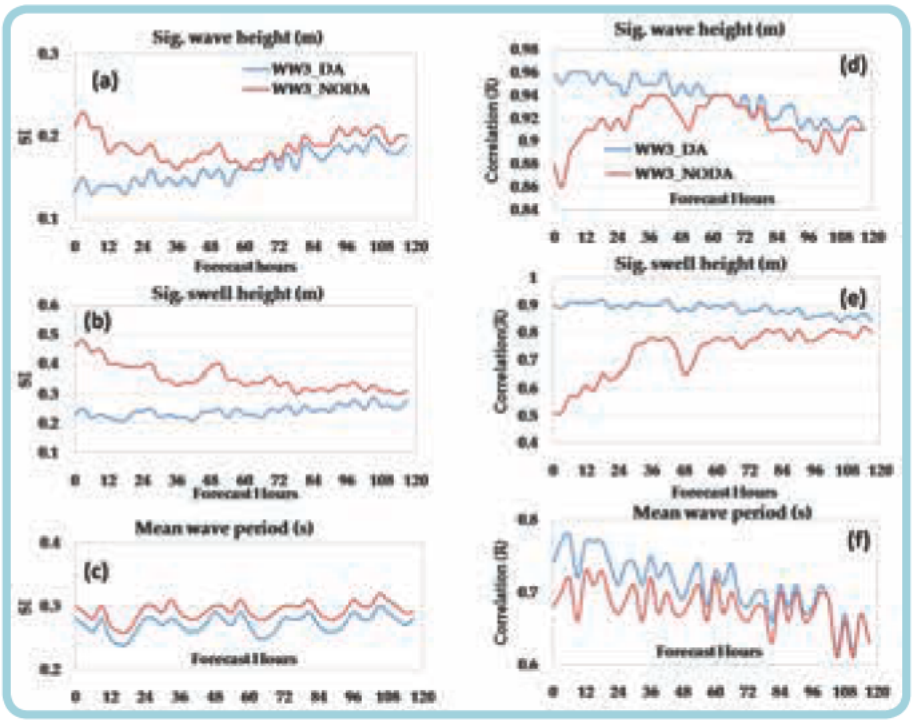
A state-of-the art operational forecasting system based on HYCOM model with data assimilation (DA) has been set up at INCOIS. This setup is the highest resolution operational system with DA available for the Indian Ocean basin compared to any operational agency in the world. The core of the system is a 1/16° eddy resolving Indian ocean Hybrid Coordinate Model (HYCOM), nested to a 1/4° Global HYCOM which provides lateral boundary conditions to the high-resolution model. The system uses data assimilation scheme based on Tentral Statistical Interpolation (T-SIS) scheme. A five-year hindcast for the period 2012 to 2016 has been carried out using both setups. Comparison of the five-year hindcast results with the observations showed that both Indian Ocean and global model simulated SST, SSS, SLA, currents and vertical structure of the ocean with good accuracy compared to other global systems like GODAS and NRL-HYCOM.



Basin wide quantitative comparison of the Zonal currents in terms of absolute bias, RMSD and Correlation from the system with NRL HYCOM & INCOIS GODAS during 2016 hindcast.

7.5. Wave Data Assimilation in WAVEWATCH III

Wave observations are of great importance for verification of the forecast. Apart from the verification, they can be assimilated in a wave model to improve the wave analysis and forecast. Hence wave height observation from three satellites Jason-2, Jason-3 and Saral-AltiKa

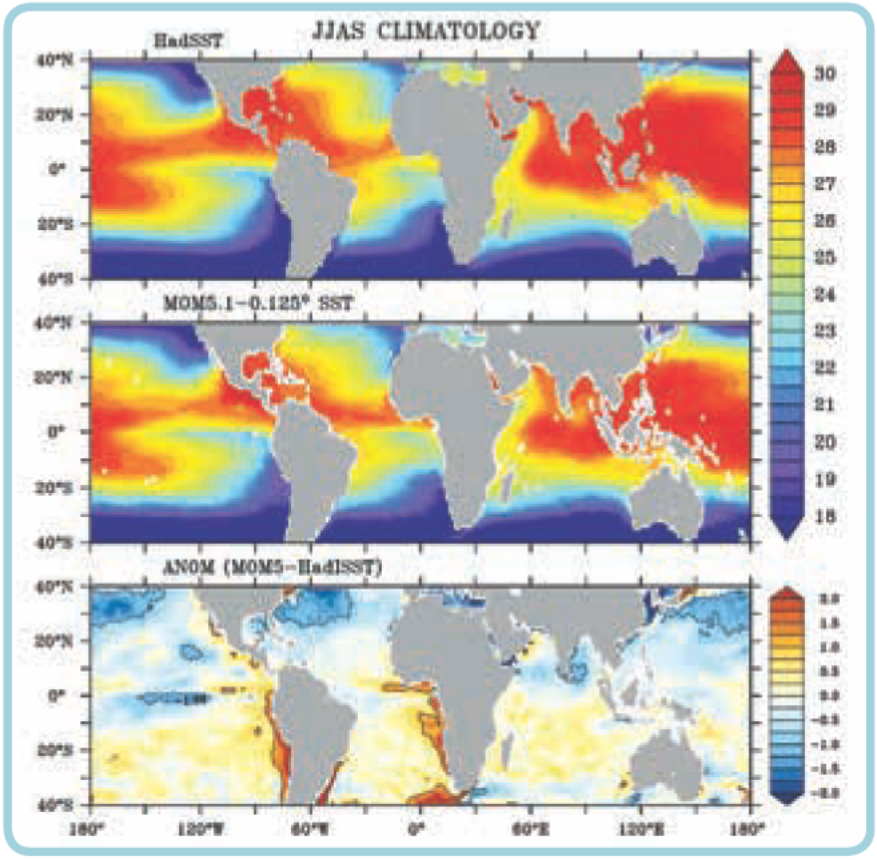


Model error statistics for the comparison with in situ wave observation of Indian Ocean as function of forecast time. Left panel Scatter index. Right panel: Correlation.

is assimilated in WAVEWATCH III model (Indian Ocean) using optimal interpolation technique. Improvement in the predicted wave parameters are clearly seen in the comparison with in situ wave observations. Swell forecasts are improved systematically more than 48 hours ahead.

7.6. Projections of Sea Level changes along the Indian coasts

It is well known that the increased emission of anthropogenic greenhouse gases (GHG) causes irreversible change in the earth's Climate. According to IPCC (The Intergovernmental Panel on Climate Change) reports, global mean sea level has been increasing over the last century at the rate of 1.8 mm yr^{-1} due to thermal expansion and ice melting. It is expected that the sea level will continue to rise in the coming century. This poses a great threat to coastal population and maritime driven economy across the globe. The problem is much severe for India due to the exposure of more than 1/3rd of its population living along the coastline of over 8000 kms long and several low-lying areas, like Sundarban and Lakshadweep Islands.



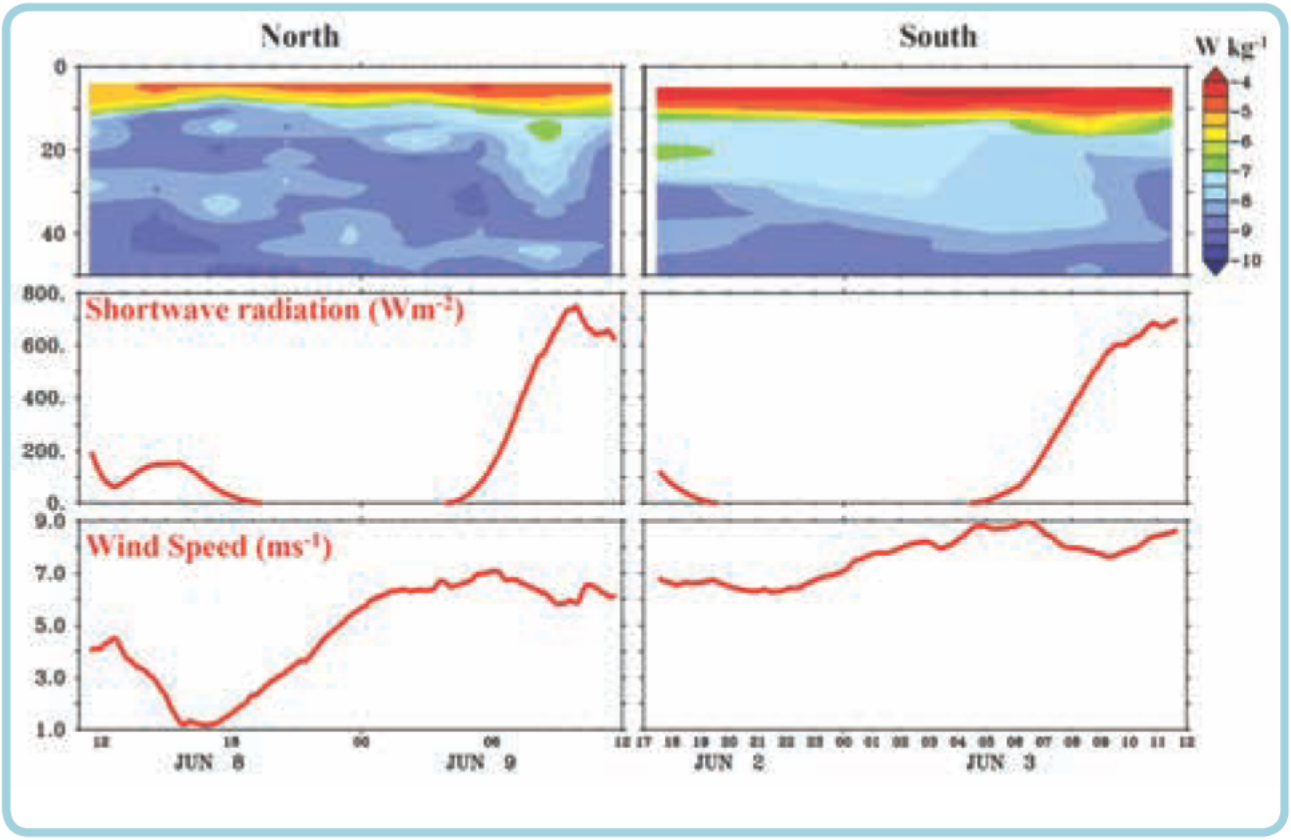
Comparison of climatological SST from observation (HadISST) and model simulation after 50th year of spin-up. Model could capture the observed SST very well and the errors are within 0.5°C over most part of the tropical region.

In order to address this issue, INCOIS is developing a system the sea level changes along the coast of India in seasonal to decadal time scales. This system consists of a suit of global and regional ocean model, forced by projected atmospheric forcing from Coupled Model Intercomparison Project (CMIP). A global model, based on Modular Ocean Model (MOM5.1) with horizontal resolution uniform 1/8° and 42 vertical levels with 22 layers in the top 200 m, of the water column has been configured. Climatological simulation of this model could reproduce the observed Sea Surface Temperature accurately.

7.7. Process Specific Observations in the Bay of Bengal and Arabian Sea

During April 2017 to March 2018, INCOIS conducted two scientific cruises on board Sagar Nidhi; one in the summer monsoon season in the Bay of Bengal (SN-120; 1-27 June, 2017; 27

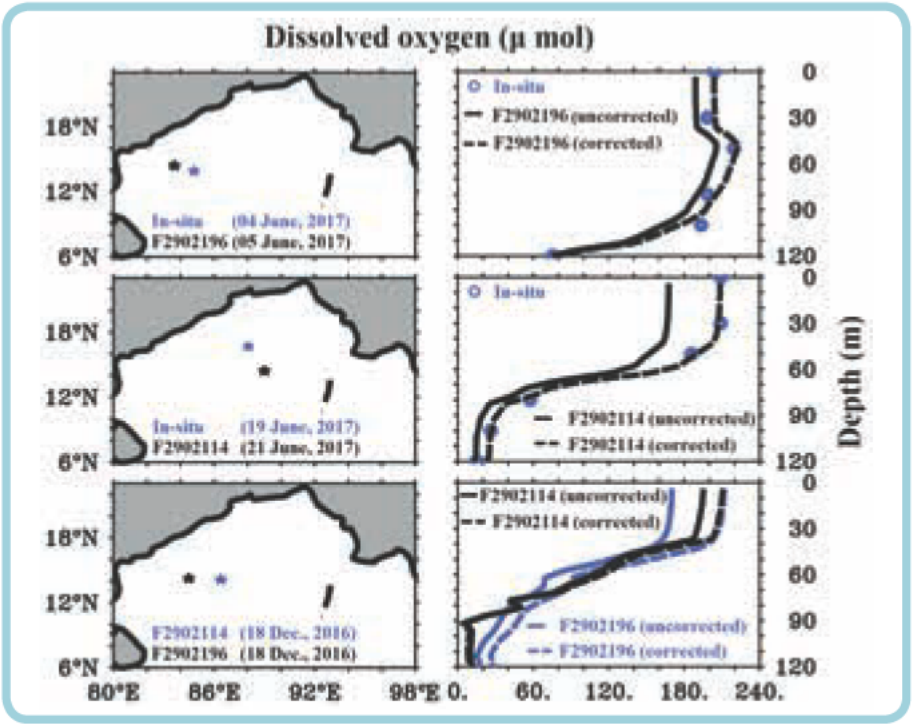
days) and another during the winter season in the Arabian Sea (SN128; 12 January, 2018-12 February, 2018; 30 days). Twenty members from different Indian institutes participated in each of the cruises. The objectives of the two cruises were to collect near surface meteorological data using ASIMET module, upper ocean temperature, salinity using uCTD, vertical distribution of small-scale turbulent characteristics using Vertical Microstructure Profiler (VMP)-250 and to document the planetary boundary layer characteristics in the Bay of Bengal during summer monsoon using radiosonde. Time-series observations using VMP for 9 continuous days were made in the northern Arabian Sea (18.45°N, 67.42°E), 3 days in the southeastern Arabian Sea (11.15°N, 73.4°E) and one day time series in southern (11.56°N, 83.33°E) and northern (20.35°N, 89.6°E) Bay of Bengal. In addition to this, VMP data in 12- hour intervals (morning and evening) along the south-north transects were also taken and radiosondes were released. Initial estimates of turbulent kinetic energy (TKE) dissipation rate (ε) estimated using the data collected by VMP in the northern and in the southern BoB during summer 2017 shows turbulence intensity of higher magnitude 10^{-4}-10^{-6} W kg^{-1} in the upper 10-15 m of water column. It is also noticed that, below 30 m depth mixing intensity is relatively weaker and is almost constant (10^{-9} W kg^{-1}). During the observation period, wind speed magnitude was relatively higher throughout the day in the southern Bay of Bengal (7 m s^{-1}) compared to north (less than 7 m s^{-1}). Consistent with the difference in the wind forcing, the TKE dissipation rate showed higher magnitude (~O (1)) in the south and it penetrates a little deeper compared to the northern Bay of Bengal.



One day time series of (top panel) turbulent kinetic energy (TKE) dissipation rate (ε) estimated from VMP in the southern and northern Bay of Bengal (middle panel) short wave radiation (Wm^{-2}) and wind speed (ms^{-1}) in the (left panel) northern Bay of Bengal (20.35°N, 89.6°E) and in the (right panel) southern (11.56°N, 83.33°E) Bay of Bengal.

It has been reported that the optical BGC sensors in the profiling floats have significant offset and it should be corrected using the in situ water sample collection. Considering this, during these

cruises, water samples were collected to estimate the BGC parameters such as dissolved oxygen, chlorophyll and nitrate during the deployment of new BGC-Argo floats as well as near the BGC-floats which were deployed earlier. It is possible to correct the bias (~30 μM) in the DO measurements from the Argo floats using this method so that a reliable long-term data for process studies as well as to validate the ecosystem model simulations.



The dissolved oxygen (μM) measurements from hydrographic cast (SN-120; blue open circle), uncorrected (black solid line) and corrected (black dashed line) dissolved oxygen measurements from the BGC-Argo floats (Top panel; Float 2902196 and middle panel; Float 2902114). (Bottom panel) uncorrected (solid line) and corrected (dashed line) of dissolved oxygen measurements from the 2902114 (black line) and Float 2902196 (blue line). Left panel shows locations of hydrographic casts (SN-120) and BGC-Argo floats corresponding to the profiles in the right panel.

7.8. Extramural Projects funded under O-MASCOT Programme

In order to meet the specific objectives of the O-MASCOT programme, proposals were invited from scientists working in research institutes/universities and having requisite expertise. Proposals received against this call were subjected to critical evaluation by external subject experts and the review reports were submitted to the Project Management Committee (PMC) for its recommendations. Based on the external review reports and the presentations made by the principal investigators, the PMC, which met on 12 March 2018 at INCOIS, recommended to fund 6 projects under O-MASCOT. The PMC also evaluated the progress of in-house R&D efforts in implementing the specific targets of O-MASCOT.

Table: List of extramural projects funded by INCOIS under O-MASCOT Programme

Name of the Principal Investigator	Title of the Project	Duration	Budget (in Lakhs)
Prof. P. N. Vinayachandran, IISc, Bangalore	Development and implementation of river discharge and biogeochemical module for the global climate model set-up of INCOIS	2017-2020	98.0
Prof. Manasa Ranjan Behera, IIT Bombay	Significance of wave-current and tide - wave interaction at various coastal locations of India	2017-2020	36.5

Dr. V. V. S. S. Sarma, NIO-RC, Visakhapatnam	Influence of anticyclonic eddies on Oxygen Minimum Zone in the Bay of Bengal	2017-2020	47.0
Prof. Jayanarayanan Kuttippurath, IIT Kharagpur	The impact of atmospheric aerosols and pollution on the Bay of Bengal Marine ecosystem.	2017-2020	36.5
Dr. Vijith V, CUSAT, Kerala	A coupled physical - ecosystem model based on MOM5 - COBALT for the Indian Ocean	2017-2020	22.5
Mr. Vijayakumar Kanojia, CSIR – NIO	Ship-based measurement of-resolution surface turbulent air- sea fluxes of heat, moisture, and momentum from the Indian ocean/Arabian sea	2017-2020	49.0

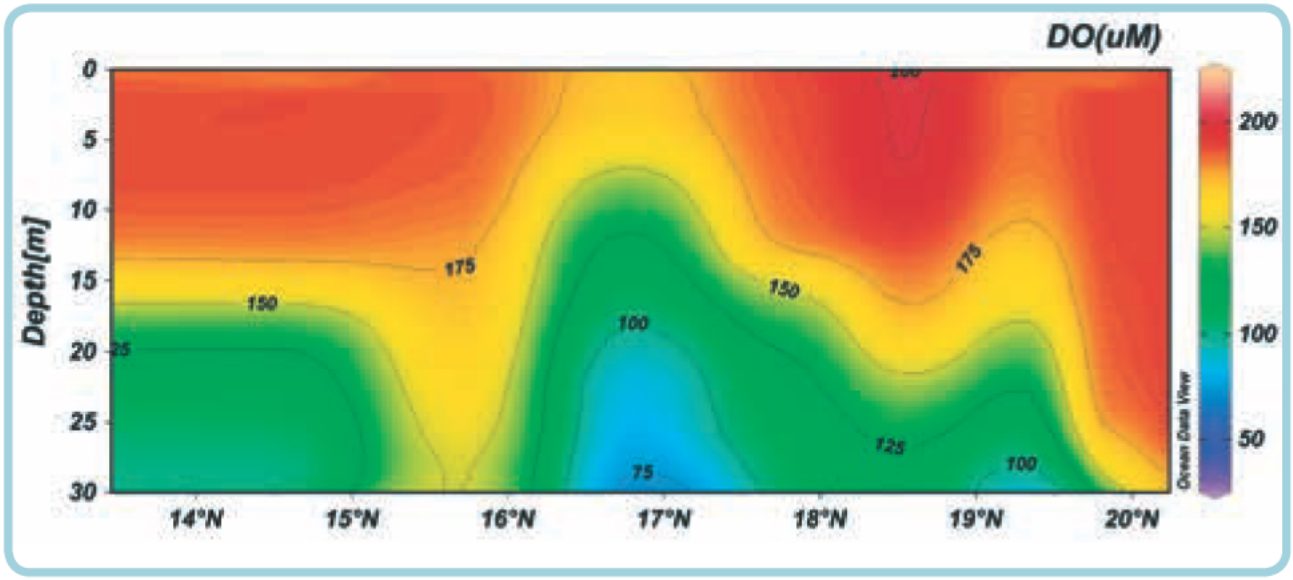
7.9 Marine Observation System Along Indian Coast (MOSAIC)

The increasing population and rapid economic growth of the countries surrounding the Arabian Sea and Bay of Bengal make these semi-enclosed seas particularly vulnerable to warming and other anthropogenic influences. A large portion of the population in the Indian sub-continent resides in coastal areas and depends on coastal ocean for their food and economy. The human impacts on the coastal ocean in terms of pollution and waste disposals have greatly modified the fluxes of material to the coastal waters. It has already been noticed that nutrients load to the coastal ocean is increasing since past three decades in the South East Asia. Natural processes such as monsoonal winds, fresh water fluxes from rivers and seasonally reversing currents, though have significant intra, inter-annual and decadal variations, add to these anthropogenic perturbations and often magnify them. Despite this the Indian coastal region remains largely unexplored and our understanding on this aspect is still primitive. The coastal hypoxia along eastern Bay of Bengal has also reportedly intensified in the past few decades. It is, therefore, imperative to monitor various biogeochemical properties over a longer period of time to assess the change and understand the processes responsible for the observed change. At present the Indian Coastal waters do not have reliable time series data to interpret and quantify the changes that might occur due to the anthropogenic activities. To

Tracks of MOSAIC pilot cruises

overcome this shortcoming, a comprehensive coastal observation has been planned to establish Marine Observation System Along Indian Coast (MOSAIC). Six coastal buoy-based automated observatories will be established as part of MOSAIC to monitor water quality parameters, develop understanding of coastal processes, assess the health of the coastal and estuarine waters and to use the data for nowcasting of water quality all around the coast. The collected data will be used for model validation, assimilation and forecasting of water quality parameters. Monthly in-situ sampling will also be carried out at the buoy location to ensure the quality of the sensor data.

As a pilot study, three scientific cruises (SM-13/2017, 21/2017 and 01/2018) were conducted in the coastal Bay of Bengal during May and October 2017, respectively. Main objectives of the cruises were to capture the variability in biogeochemical parameters in the coastal waters of



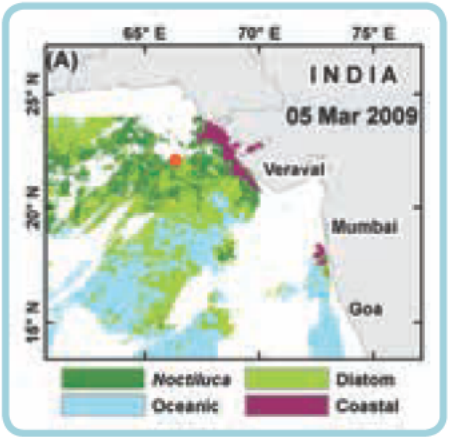
Vertical section of dissolved oxygen (DO) measured during the coastal cruise.

the Bay of Bengal, studying the impact of river water discharge on coastal ecosystem at select locations, understanding physical-biological interactions in the coastal waters and to develop algorithms to derive geophysical parameters for coastal waters. Water samples were collected along 30-100 m water depths for the estimation of chlorophyll, pigments, nutrients and size-fractionated absorption. Radiometers were also operated to measure the optical characteristics of coastal waters. Preliminary results indicate that the surface waters are under-saturated in terms of DO. The preliminary analysis of nutrient data also suggested that the waters on the east coast are silicate stressed and productivity is limited due to unavailability of dissolved silica in surface waters.

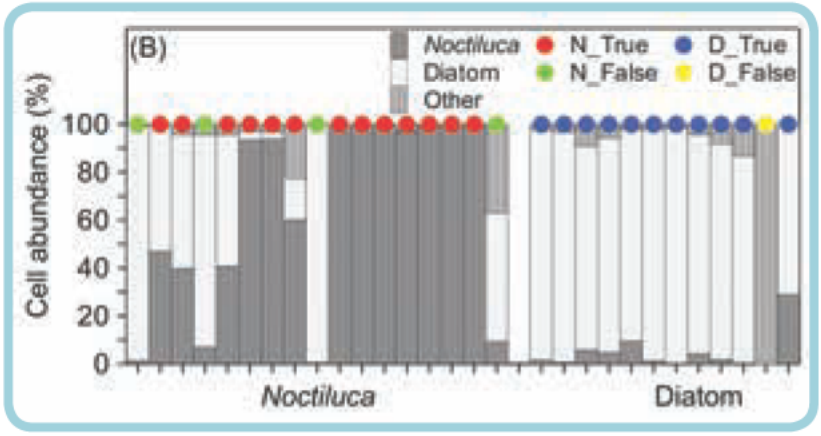
7.10. SATellite Coastal and Oceanographic REsearch (SATCORE)

7.10.1. Satellite remote sensing of Northeastern Arabian Sea algal bloom

Intense blooms of the heterotrophic dinoflagellate, green *Noctiluca scintillans*, have been reported annually in the Northern Arabian Sea since the early 2000s. A study was carried out using satellite data to determine the distribution of both diatom and green *Noctiluca* blooms in the Northeastern Arabian Sea from 2009 to 2016. The results from shipboard microscopy of phytoplankton community composition were used to validate the satellite estimates. The satellite algorithm showed 76% accuracy for the detection of green *Noctiluca* and 92% for diatoms.



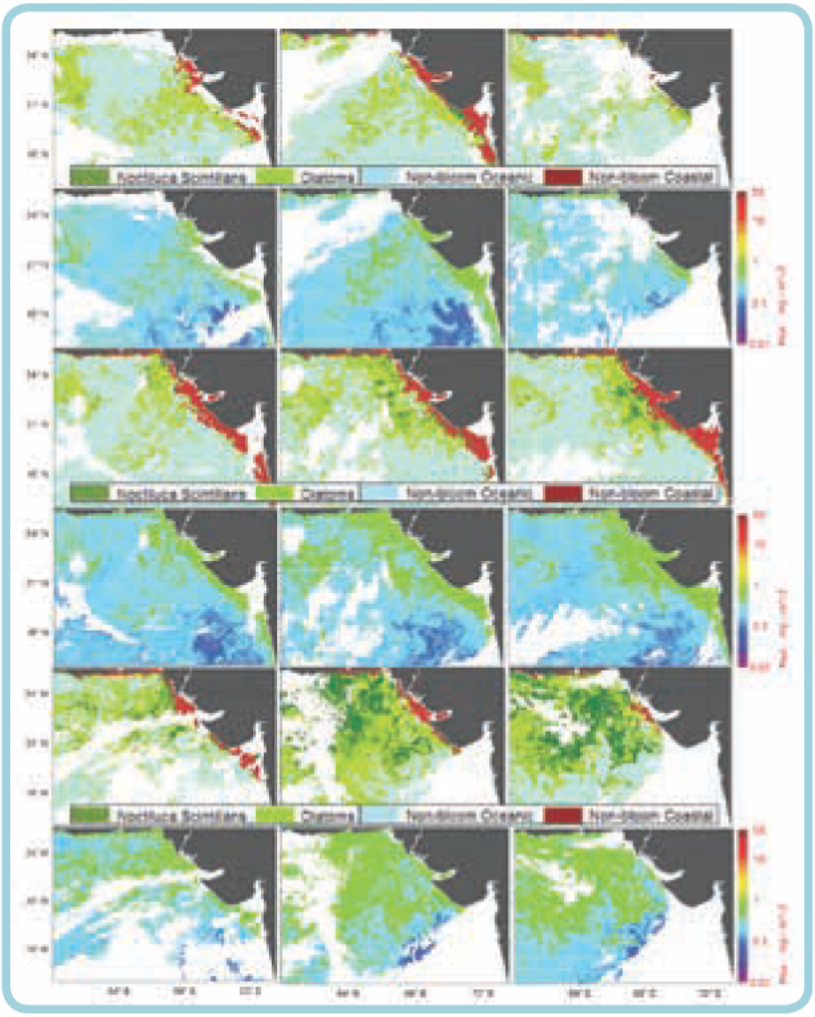
Spatial distribution of green Noctiluca, diatom, non- bloom oceanic and coastal waters derived from MODISA. Red solid circles denote the confirmation of green Noctiluca bloom using in situ data.



In situ abundance (%) of Noctiluca, diatom and other phytoplankton (hatched bars) compared to the assignment of a pixel to Noctiluca or diatom using the satellite algorithms.

7.10.2. Abundance of smaller phytoplankton during Noctiluca bloom

A study was carried out to discern the distribution of phytoplankton size classes during green *Noctiluca* bloom. Different size classes of phytoplankton such as pico, nano and micro were quantified in the water column of the bloom and non-bloom regions. In surface waters of bloom, the micro, nano and picophytoplankton contributed 60.5%, 7.1% and 32.4% respectively to the total phytoplankton biomass. Spatio-temporal imageries of phytoplankton depicted prevalence of diatom during January. Subsequently, signatures of green *Noctiluca* proliferation were observed over the diatom patches in mid- February which increased and sustained till March. Despite bloom conditions, picophytoplankton contributed more than 30% to the total phytoplankton biomass which could be due to non-predation of green *Noctiluca* on picophytoplankton flora.

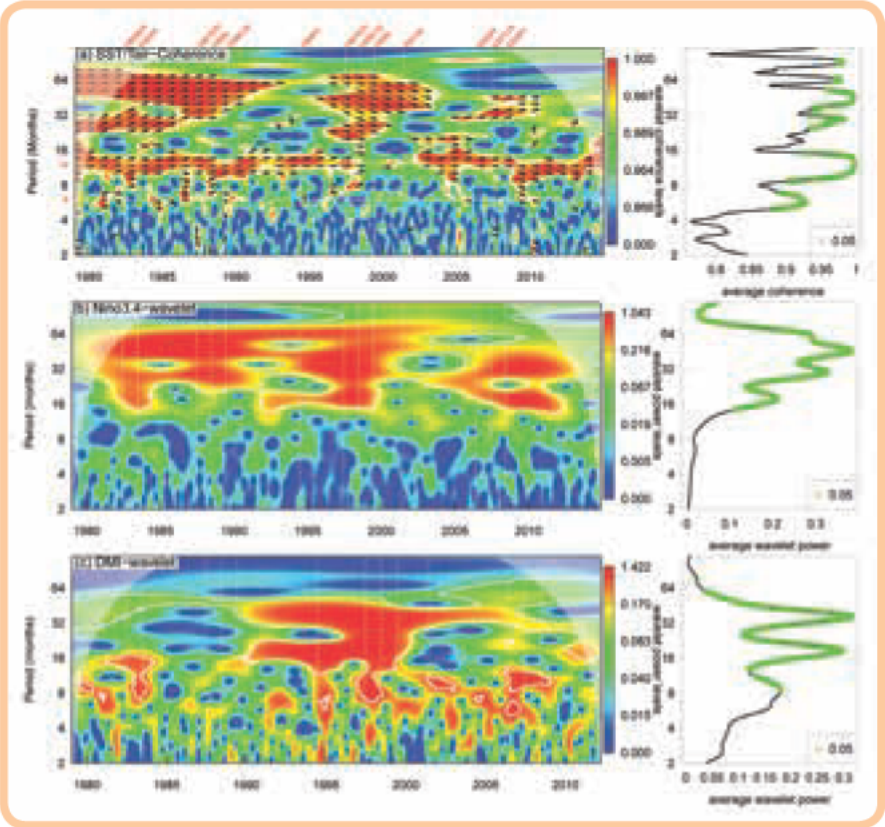


Satellite (MODISA) retrieved temporal distribution of diatom-green Noctiluca (a-c, g-i, m-o) and picophytoplankton (d-f, j-l, p-r) during winter of 2016 in the northern Arabian Sea.

8. Research Highlights

8.1. Ocean atmosphere thermal decoupling in the eastern equatorial Indian ocean

Analysis of SST and air temperature (Tair) from TROPFLUX, HYCOM and RAMA buoys showed evidence for instantaneous ocean-atmosphere thermal decoupling in the Eastern Equatorial Indian Ocean. The analysis demonstrated that a perpetual low correlation region co-located with lower wind-stress and lower surface heat flux exists in the EEIO. The region is also characterised with highest SST in the basin. As precipitation plays a significant role in the rapid decrease of Tair, with no such drop in SST in the sub-monthly time-scale, the correlation between Tair and SST is very low. The SST variability associated with MJO wind forcing in the EEIO is half that of other regions with strong wind forcing. More humid and near saturated atmosphere over the warmer ocean with higher SST reduces the dependence of SST on winds through fluxes. However, the higher SST leads to precipitation, a rapid drop in Tair and delayed response in SST after the passage of MJO, resulting in lower correspondence between them. As the winds are minimum in the EEIO, the remote forcing imparted by waves along the equatorial wave-guide play a larger role in determining the thermal structure of the EEIO compared to direct thermal forcing through fluxes or wind mixing. The remote dynamical forcing dominantly operates in the region at semi-annual frequency through equatorial waves. Thus, in the EEIO, the wave- induced thermal changes in ocean surface not mimicked by the atmosphere contributes to low correlation at the semi-annual frequency. A wavelet analysis



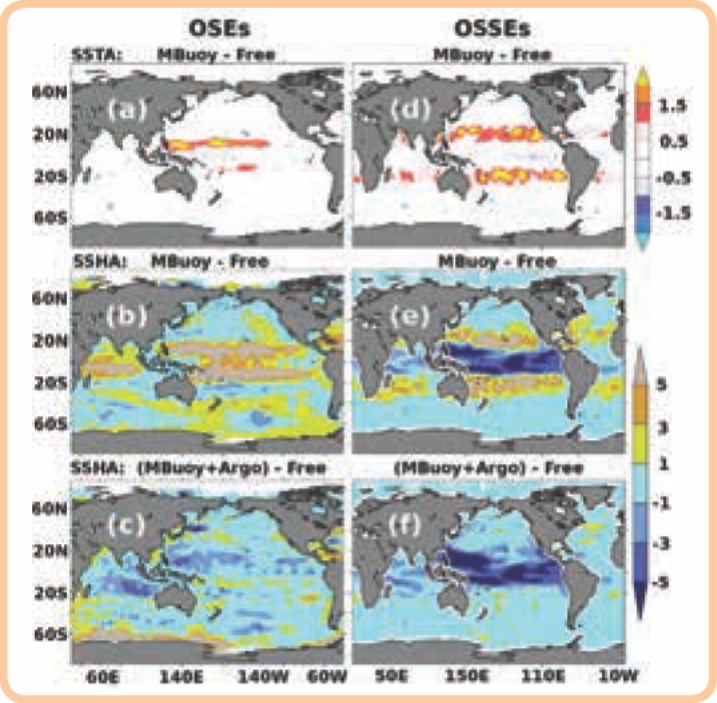
Wavelet coherence computed using monthly mean time-series of SST and Tair from EEIO. Arrows indicate phase angle, which are plotted where they are significant at 95 %. White colour contours indicate coherence significant at 95 %. Cone of influence is indicated by semi-transparent white envelope. Plots in (black line) second column shows average coherences corresponding to each frequency in respective locations. Green circle envelope indicates average coherence significant at 95 %. Major interannual events happened during the period of analysis is marked with their year (white dashed vertical lines) and codes in red colour at top horizontal axis (EPI = El-Niño + Positive IOD, PI = Positive IOD, L = La Niña, LNI = La Niña + Negative IOD, NI = Negative IOD). b) Wavelet power of Niño-3.4 index and c) wavelet power of DMI (only up to 2012)

REF: Joseph, S., Ravichandran, M., Kumar, B.P., Jampana, R.V., Han, W. Ocean atmosphere thermal decoupling in the eastern equatorial Indian ocean (2017) Climate Dynamics, 49 (1-2), pp. 575-594.

of SST and Tair showed that relatively higher coherence exists between them during ENSO-IOD events, though there is lower co-variability at other frequencies below annual periodicity. Thus, ENSO-IOD events manifest as positive contributors to SST-Tair correlation at inter-annual scale, while breaking it at the annual frequency. The annual warming of ocean and atmosphere in the EEIO region is the main contributor to the limited correlation observed in the EEIO during non-IOD/ENSO years. The above results warrant an in-depth analysis of co-variability between SST and Tair during events of IOD and ENSO, which will be a future work of utmost interest to the understanding of coupled ocean-atmosphere processes.

8.2. Possible errors in the pre-Argo ocean reanalyses

Assimilation methods, meant to constrain divergence of model trajectory from reality using observations, do not exactly satisfy the physical laws governing the model state variables. This allows mismatches in the analysis in the vicinity of observation locations where the effect of assimilation is most prominent. These mismatches are usually mitigated either by the model dynamics in between the analysis cycles and/or by assimilation at the next analysis cycle. However, if the observations coverage is limited in space, as it was in the ocean before the Argo era, these mechanisms may be insufficient to dampen the mismatches, which we call shocks, and they may remain and grow. Through controlled experiments, using real and simulated observations in two different ocean models and assimilation systems, it was shown that such shocks are generated in the ocean at the lateral boundaries of the moored buoy network. They thrive and propagate westward as Rossby waves along these boundaries. However, these shocks are essentially eliminated by the assimilation of near-homogenous global Argo distribution. These findings question the fidelity of ocean reanalysis products in the pre-Argo era. For example, a reanalysis that ignores Argo floats and assimilates only moored buoys, wrongly represents 2008 as a negative Indian Ocean Dipole year.

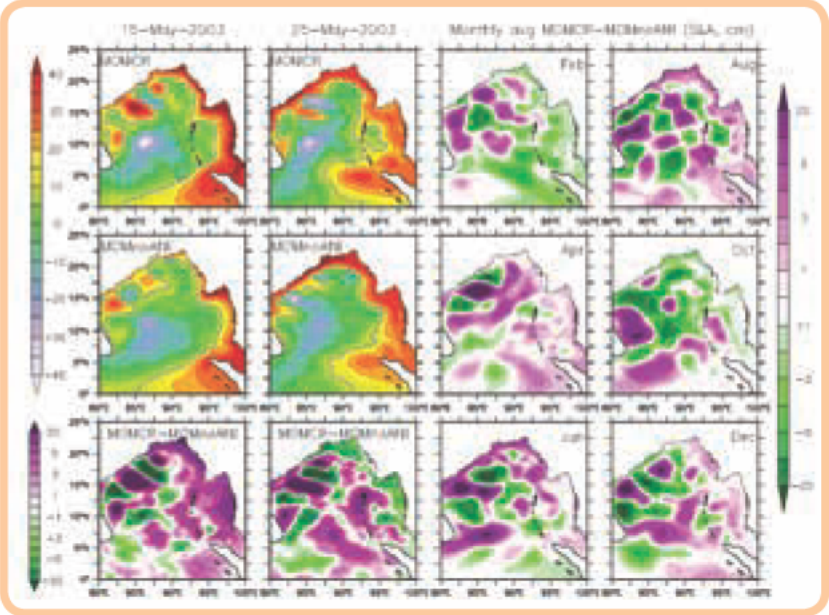


RMSE differences between free and assimilation experiments in OSEs (a,b,c) and OSSEs (d,e,f). Panels (a,d) show RMSE differences in SSTA (°C) between MB and FR. Panels(b,e) show RMSE differences in SSHA (cm) between MB and FR. Similarly, panels (c,f) show RMSE differences in SSHA (cm) between MB+ AR and FR. In the figure positive (negative) values indicate degradation (improvements) from the assimilation experiment with respect to free experiment. RMSE for each OSSEs is computed with respect to Nature run, whereas in OSEs it is computed with respect to satellite-based SST observations of TMI/AMSRE and satellite altimeter based SSHA global maps from AVISO.

REF: Sivareddy, S., Paul, Arya, Sluka Travis, Ravichandran, M., Kalnay, Eugenia. The pre-Argo ocean reanalyses may be seriously affected by the spatial coverage of moored buoys. Scientific Report. 7, 46685; doi: http://dx.doi.rg/10.1038/srep46685

8.3. Andaman Sea circulation and equatorial Indian Ocean - Bay of Bengal connection

Circulation in the Bay of Bengal (BoB) is driven not only by local winds, but are also strongly forced by the reflection of equatorial Kelvin waves (EKWs) from the eastern boundary of the Indian Ocean. The equatorial influence attains its peak during the monsoon-transition period when strong eastward currents force the strong EKWs along the equator. The Andaman Sea, lying between the Andaman and Nicobar island chains to its west and Indonesia, Thailand, and Myanmar to the south, east, and north, is connected to the equatorial ocean and the BoB by three primary passages, the southern (6.8 °N), middle (10.8 °N), and northern (15.8 °N) channels. With the help of ocean circulation models, together with satellite altimeter data, the pathways by which equatorial signals pass through the Andaman Sea to the BoB and associated dynamical interactions in the process was studied. It was found that the mean coastal circulation within the Andaman Sea and around the islands is primarily driven by equatorial forcing, with the local winds forcing a weak sea-level signal. On the other hand, the current forced by local winds is comparable to that forced remotely from the equator. These results suggest that the Andaman and Nicobar Islands not only influence the circulation within the Andaman Sea, but also significantly alter the circulation in the interior bay and along the east coast of India, implying that they need to be represented accurately in numerical models of the Indian Ocean.



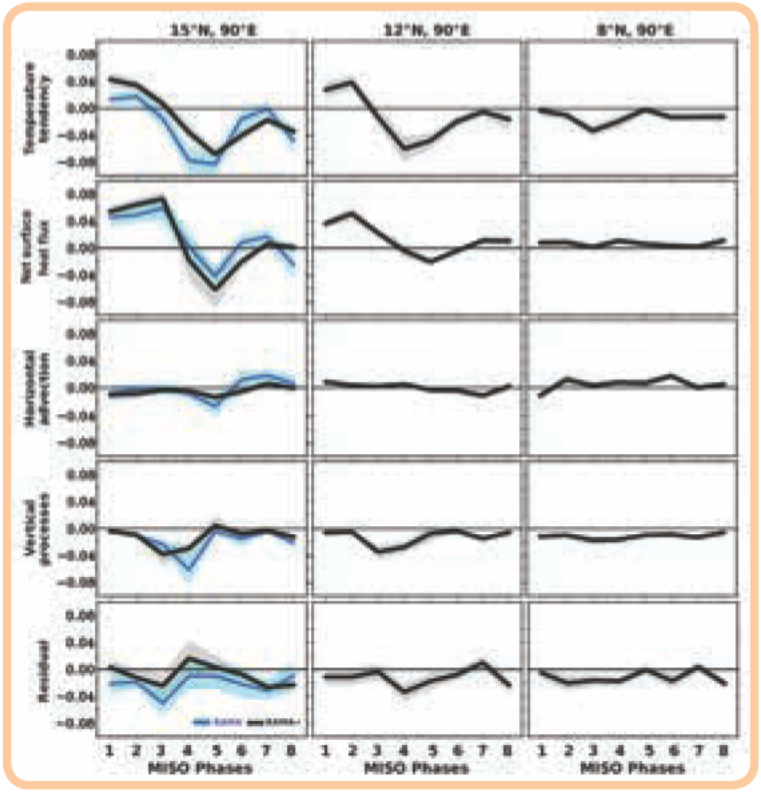
Comparison of solutions (SLAs, cm) MOMCR (MOM control run), and MOMnoANI (MOM without the Andaman and Nicobar Islands). The first two columns compare the snapshotsfrom these two solutions, with the bottom plots showing the difference between MOMCR and MOMnoANI. The last two columns show the difference between the monthly averaged SLAs in MOMCR and MOMnoANI. All results are for 2003.

REF: Chatterjee, A., D. Shankar, J. P. McCreary, P. N. Vinayachandran, and A. Mukherjee (2017), Dynamics of Andaman Sea circulation and its role in connecting the equatorial Indian Ocean to the Bay of Bengal, Journal of Geophysical Research. Oceans, 122 (4), pp. 3200-3218.

8.4. Oceanic response to the summer Monsoon Intraseasonal Oscillation (MISO) in the Central Bay of Bengal

Composite analyses of mixed layer temperature (MLT) budget terms from near-surface meteorological and oceanic observations in the central Bay of Bengal are utilized to evaluate the modulation of air- sea interactions and MLT processes in response to the summer monsoon intraseasonal oscillation (MISO). For this purpose, we use moored buoy data at 15.8 °N, 12.8 °N, and 8.8 °N along 90.8 °E together with TropFlux meteorological parameters and the Ocean Surface Current Analyses Real- time (OSCAR) current product. Our analysis shows a strong cooling tendency in MLT with maximum amplitude in the central and northern BoB during the northward

propagation of enhanced convective activity associated with the active phase of the MISO; conversely, warming occurs during the suppressed phase of the MISO. The surface mixed layer is generally heated during convectively inactive phases of the MISO primarily due to increased net surface heat flux into the ocean. During convectively active MISO phases, the surface mixed layer is cooled by the combined influence of net surface heat loss to the atmosphere and entrainment cooling at the base of mixed layer. The variability of net surface heat flux is primarily due to modulation of latent heat flux and shortwave radiation. Shortwave is mostly controlled by an enhancement or reduction of cloudiness during the active and inactive MISO phases and latent heat flux is mostly controlled by variations in air-sea humidity difference.

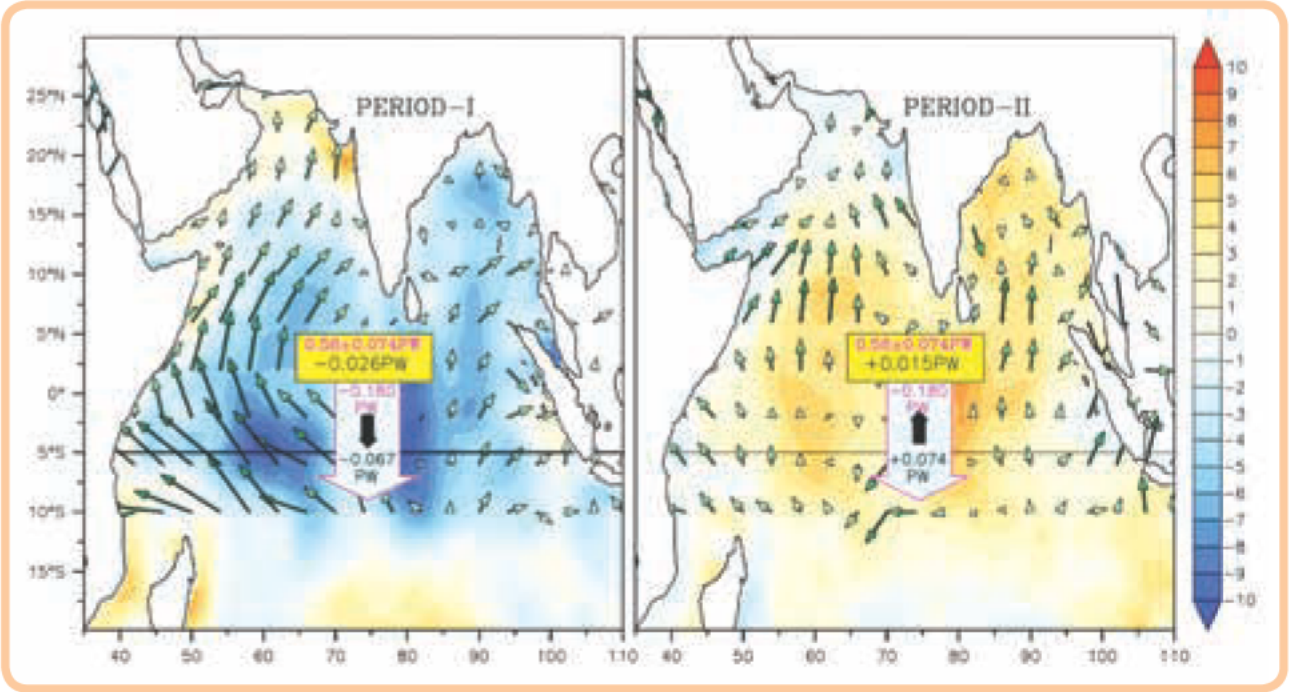


Composite of different terms in the MLT budget equation (temperature tendency, net surface heat flux, horizontal advection, vertical process, and residual) under different MISO phases based on RAMA (blue line) and RAMA+ (blackline) analyses at (left plot) 15.8 °N, 90.8 °E, (middle plot) 12.8 °N, 90.8 °E, and (right plot) 8.8 °N, 90.8 °E in the BoB. The blue and grey-shading indicates one standard error for RAMA and RAMA+ based analyses. Unit: °C d^{-1}.

REF: Girishkumar, M.S., Joseph, J., Thangaprakash, V.P., Pottapinjara, V., Mcphaden, M.J., Mixed Layer Temperature Budget for he Northward Propagating Summer Monsoon Intraseasonal Oscillation (MISO) in the Central Bay of Bengal (2017) Journal of Geophysical Research: Oceans, 112(11), pp. 8841-8854.

8.5. Reversal of North Indian Ocean decadal sea level trend in recent two decades

A distinct reversal of the North Indian Ocean (NIO, north of 5°S) sea level decadal trend between 1993– 2003 and 2004–2013, after the global mean sea level rise is removed is observed in the satellite and in- situ observations, ocean reanalysis products and model simulations. Sea level falls from 1993 to 2003 (Period I) but rises sharply from 2004 to 2013 (Period II). Steric height, which is dominated by thermosteric sea level of the upper 700 m, explains most of the observed reversal, including the spatial patterns of sea level change. The decadal change of surface turbulent heat flux acts in concert with the change of meridional heat transport at 5°S, with both being driven by decadal change of surface winds over the Indian Ocean, to cause sea level fall during Period I and rise during Period II. While the effect of surface net heat flux is consistent among various data sets, the uncertainty is larger for meridional heat transport, which shows both qualitative and quantitative differences amongst different reanalyses. The effect of the Indonesian Throughflow on heat content and thus thermosteric sea level is limited to the South Indian Ocean, and has little influence on the NIO. These results point to the importance of surface winds in causing decadal sea level change of the NIO.

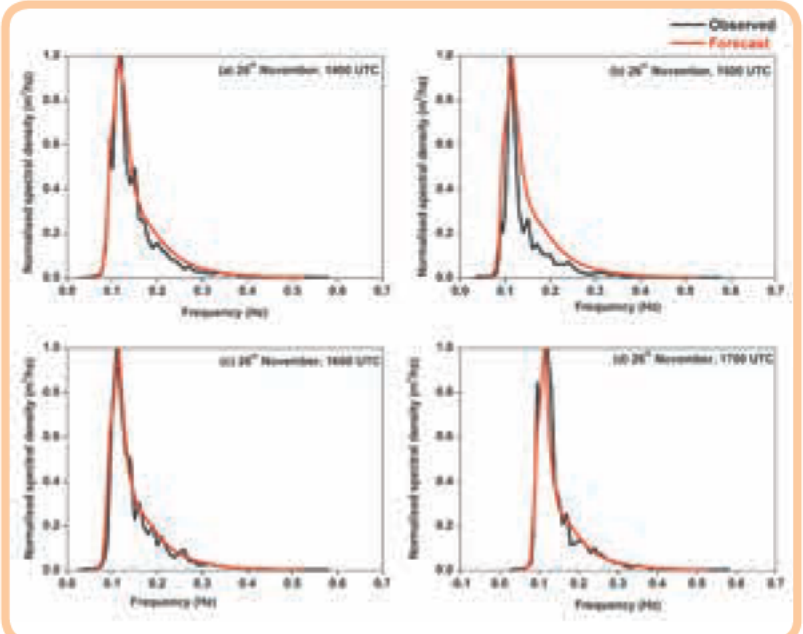


Schematic diagram summarizing the mechanism of the NIO decadal sea level reversal near 2003: the background colour refers to surface net heat flux (Wm^{-2}) anomaly (ensemble average of Tropflux, ERA- interim and NOCS products). The NIO has 0.026 PW surface heat flux deficit in Period I and 0.015 PW surplus in period II, compared to long term mean surface net heat flux (0.56 PW; the consensus value among the four surface net heat flux products mentioned above). See values in the yellow boxes. Vectors show wind speed anomalies for each period, which are more coherent (resembling annual wind pattern) over the NIO during Period I and drive stronger southward heat transport. In Period II, surface winds are dispersed, driving a weaker southward heat transport. Mean southward transport is shown in magenta colour (−0.18PW; from the more reliable ORAS4 reanalysis data) within the bulk cyan arrow. The anomaly values are shown in black font. The dark arrows within the bulk arrows show the anomalous heat transport across 5°S

REF: Srinivasu, U., Ravichandran, M., Han, W., Sivareddy, S., Rahman, H., Li, Y., Nayak, S. Causes for he reversal of North Indian Ocean decadal sea level trend in recent two decades (2017) Climate Dynamics, 49 (11-12), pp. 3887-3904.

8.6. Accuracy of wave forecast in the north Indian Ocean during extreme and calm conditions

The accuracy of the operational ocean state forecast system at ESSO-INCOIS during extreme events as well as calm conditions for a lead time of 24, 72 and 144 h were evaluated by comparing the predicted wave parameters (significant wave height, mean wave period and mean wave direction) with in situ data during three cyclones (Sidr, Khai Muk and Nisha) that occurred in the Bay of Bengal (BoB). Forecasts generated by Mike 21 SW model, with 24 and 72 h lead time showed good agreement with in situ data. Error statistics obtained



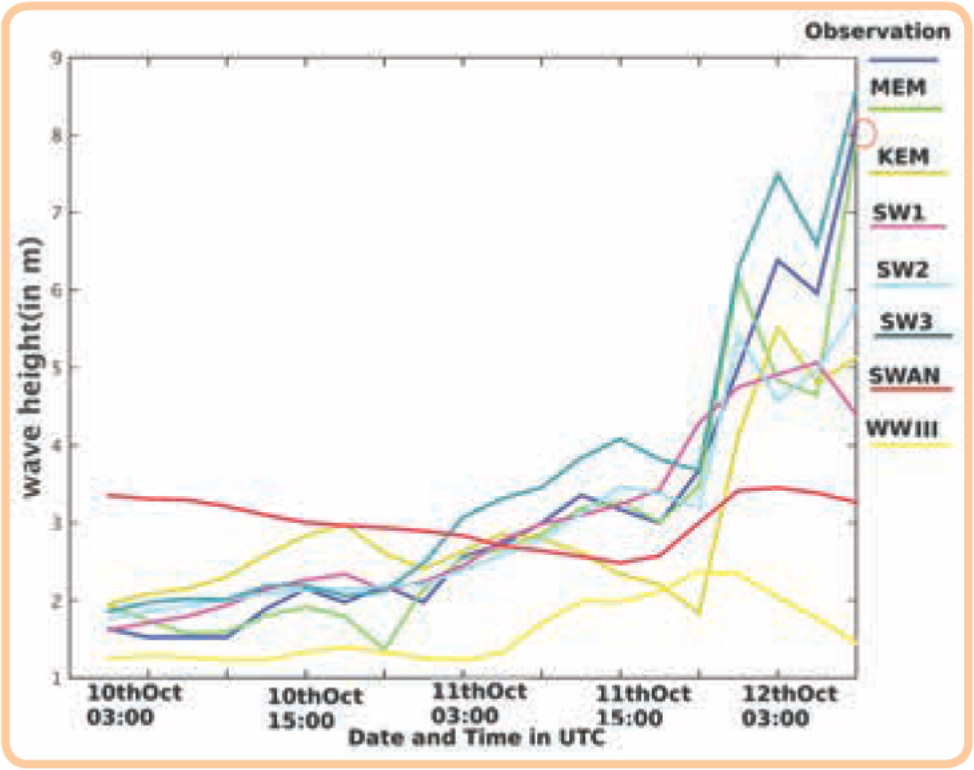
Comparison of one dimensional wave spectra at Pondicherry during Nisha cyclone

REF: Sirisha, P., Sandhya, K.G., Balakrishnan Nair, T.M., Venkateswara Rao, B. Evaluation of wave forecast in the north Indian Ocean during extreme conditions and winter monsoon (2017) Journal of Operational Oceanography, 10 (1), pp. 79-92.

during extreme events (SI < 30%, correlation coefficient > .75) suggested that the quality of the wave forecasts is very good and the model can be used for issuing high wave alerts. The two- dimensional energy spectra from the wave model during the Sidr cyclone period showed the capability of the model to simulate wind seas and swells even under cyclonic conditions. During winter monsoon, the error statistics obtained in the BoB suggested that the quality of the forecasts are good with 24- and 72-h lead time.

8.7. Multi-model super-ensemble technique for forecasting of wave height

Generally, a number of wave forecast are available for the same region from different wave models. The wave forecasts available at the Indian National Centre for Ocean Information Services from different wave models were merged using a fine-tuned multi-model super-ensemble method based on linear regression technique to obtain an improved wave forecast during extreme weather conditions. Wave forecasts generated by Multigrid WAVEWATCH III, Simulating WAves Nearshore and MIKE 21 Spectral Waves were used generate the multi-model ensemble forecast. Significant wave height up to 24-h lead time in the Indian Ocean for three different cyclones (Nilofar, Hudhud and Phailin) and during the southwest monsoon were generated using this method. A comparison of ensemble predictions and individual model predictions with the actual observations showed generally satisfactory performance of the multi- model ensemble approach. This approach was found to have more accurate wave forecasts during the severe cyclones such as Hudhud and Phailin.

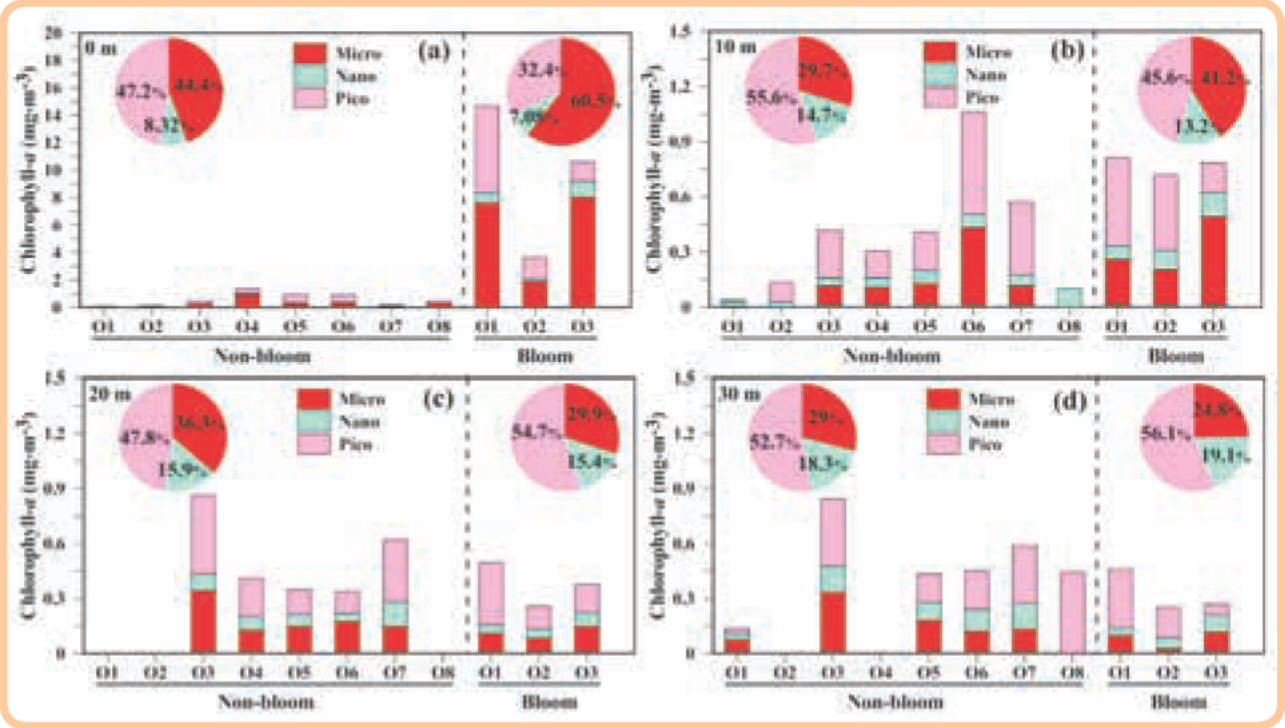


Significant wave height (in metre) is plotted for different model outputs, observation and ensemble predictions at the time of cyclone Hudhud.

REF: Majumder, S., Balakrishnan Nair, T.M., Sandhya K.G., Remya, P.G., Sirisha, P., Modification of a linear regression-based multi-model super-ensemble technique and its application in forecasting of wave height during extreme weather conditions (2018) Journal of operational oceanography, 11(1), pp.1-10.

8.8. Response of phytoplankton community and size classes to green Noctiluca bloom in the northern Arabian Sea

A comprehensive analysis on the phytoplankton ecology with special reference to different phytoplankton size classes was carried out at green Noctiluca scintillans (hereafter Noctiluca) bloom and non-bloom locations in offshore waters of the northern Arabian Sea. At the bloom locations, green Noctiluca represented a dense monospecific proliferation with average cell density of 10.16 ±



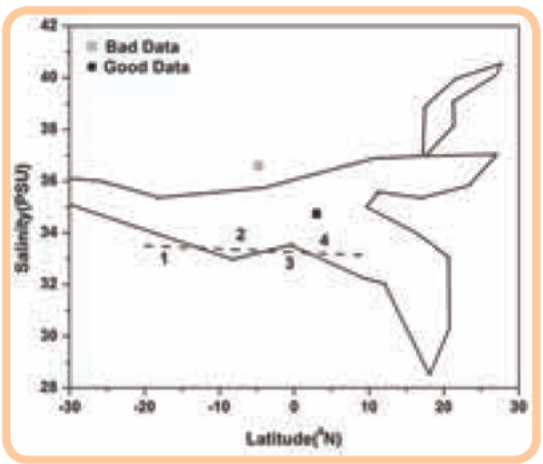
Chlorophyll-a (chl-a) concentration (in mgm^{-3}) of pico, nano and microphytoplankton at (a) surface, (b) 10 m, (c) 20m and (d) 30m depths of green Noctiluca bloom and non-bloom stations in the northern Arabian Sea. The inset pie charts show average percentage contribution of micro, nano and picophytoplankton.

REF: Baliarsingh, S.K., Lotliker, A.A., Sudheesh, V., Samanta, A., Das, Sourav, Vijayan, A.K., Response of phytoplankton community and size classes to green Noctiluca bloom in the northern Arabian Sea, (2018) Marine Pollution Bulletin, 129 (1), pp. 222-230.

5.806×104 cells-L−1 and relative abundance share of 98.63%. Active photosynthesis through prasinophytic endosymbiont was depicted from net community production magnitude reaching 85.26 mgC m^{-3} day^{-1} under low prey abundance. Parallel swarming of *Porpita porpita*, a voracious copepod feeder signified the competitive advantage of *Noctiluca* to have the phytoplankton prey. Average concentration of picophytoplankton biomass was eleven times lower in surface waters of nonbloom stations in comparison to bloom. Higher N:P ratio in subsurface waters of non-bloom stations signified non-utilization of nitrogenous nutrients. Green *Noctiluca* bloom onset subsequent to diatom rich conditions was evident from spatio-temporal ocean colour satellite imagery.

8.9. Convex Hull method to Quality control Argo data

A new method of identifying anomalous oceanic temperature and salinity (T/S) data from Argo profiling floats was proposed. The proposed method uses World Ocean Database 2013 climatology to classify good against anomalous data by using convex hulls. An n-sided polygon (convex hull) with least area encompassing all the climatological points was constructed using Jarvis-



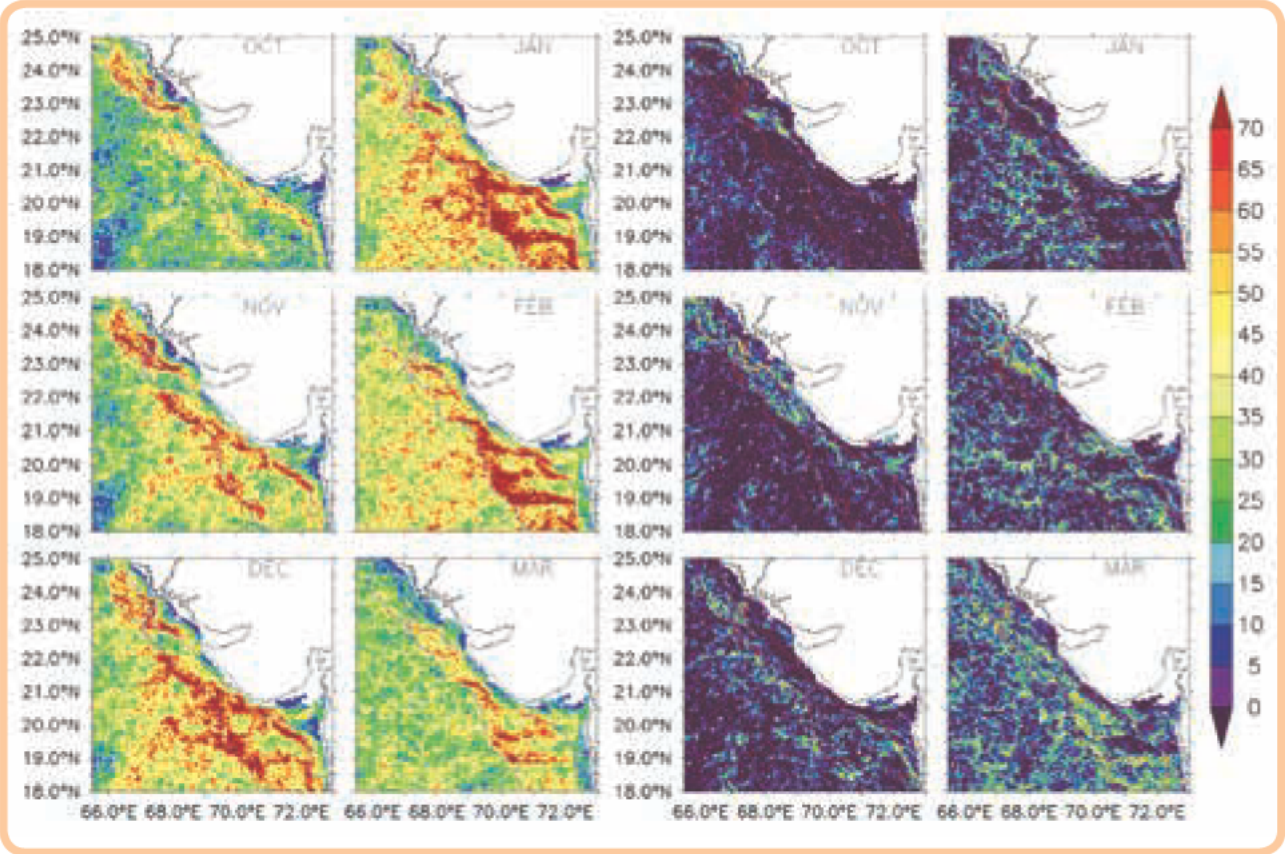
Generation of n-sided polygon (convex hull) based on the quality controlled climatological World Ocean Database 2013 and classification of good (filled square) and bad (crossed circle) data based on PIP and Jordan Curve Theorem. The number of intersections (numbered as 1–4 in figure) for a ray passing from the exterior of the polygon to any point; if odd, it shows that the point lies inside the polygon. If it is even, the point lies outside the polygon.

REF: Udaya Bhaskar, T.V.S., Venkat Shesu, R., P. Boyer, Timo hy, Rama Rao, E. P, Quality control of oceanographic in situ data from Argo floats using climatological convex hulls, (2017) MethodsX, 4, pp. 469-479.

March algorithm. Subsequently Points In Polygon (PIP) principle implemented using ray casting algorithm was used to classify the T/S data as within or without acceptable bounds. It was observed that various types of anomalies associated with the oceanographic data viz., spikes, bias, sensor drifts etc can be identified using this method. Though demonstrated for Argo data it can be applied to any oceanographic data. The patterns of variation of the parameter (temperature or salinity) corresponding to a particular depth, along the longitude or latitude can be used to build convex hulls. This method can be effectively used for quality control by building Convex hulls for various observed depths corresponding to biogeochemical data which are sparsely observed.

8.10. Persistence of productive surface thermal fronts in the northeast Arabian Sea

The persistence of sea surface thermal fronts at seasonal and non-seasonal cycles was demonstrated based on the frequency of Sea Surface Temperature gradient derived from daily gridded (5 km x 5 km) SST data from NOAA-AVHRR. Prominent thermal fronts were observed in the northeast Arabian Sea between the 50m bathymetry contour and continental self-break (~200 metre contour). A total of 45–75% of thermal fronts occurred in the annual timescales whereas 20–30% occurred in the semi-annual time-scales. Maximum frequency occurrence was observed in the coastal waters south and southwest of Saurashtra peninsula during February and March. Primary productivity co-varies with the frequency of the thermal fronts with a time-lag of 2–4 weeks. This outcome can help with timely and reliable prediction of biologically productive zones.

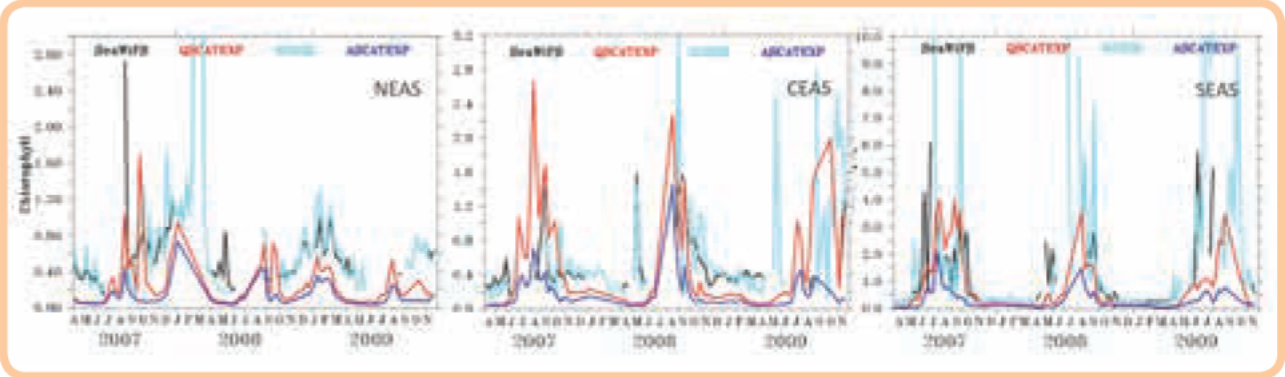


Monthly climatology of thermal front percentage frequency at seasonal (left panel) and non-seasonal (right panel) cycles for the period of October–March during years 2000–2003.

REF: Mohanty, P.C., Mahendra, R.S., Nayak, R.K., Nimit K., Srinivasa Kumar, T., Dwivedi, R.M. Persistence of productive surface thermal fronts in the northeast Arabian Sea (2017) Regional Studies in Marine Science, 16, pp. 216-224.

8.11. Getting the right wind-forcing for an ecosystem model: A case study from the eastern Arabian Sea

The state of the ocean simulated through a numerical model is extremely sensitive to the forcing and hence, the choice of appropriate forcing is essential, in particular wind-fields. Simulations of Regional Ocean Modelling System (ROMS) when forced with two different wind-fields derived from satellite sensors (scatterometers), namely QuickSCAT and ASCAT, while keeping the remaining configurations the same were compared. This study had been carried out during the operational overlapping period of these scatterometers (2007–2009). It was observed that the simulations of upper ocean chlorophyll distribution and depth of sub-surface chlorophyll maximum were vastly diverging when the model was forced with different scatterometer forcings. In order to determine which of the forcings yielded coastal productivity closer to observations, model-simulated upper ocean chlorophyll concentration with in situ observations along the eastern Arabian Sea were validated with insitu observations. For all the sub- regions, the QuickSCAT wind-forced coastal productivity was better correlated with in situ chlorophyll than its counterpart. However, this signature was most prominent in the wind-driven upwelling regime of the south-eastern Arabian Sea. Additionally, when compared with surface chlorophyll derived from SeaWiFS and MODIS Aqua satellites, it was found that the QuickSCAT simulated interannual variability was in better agreement in comparison with its counterpart.

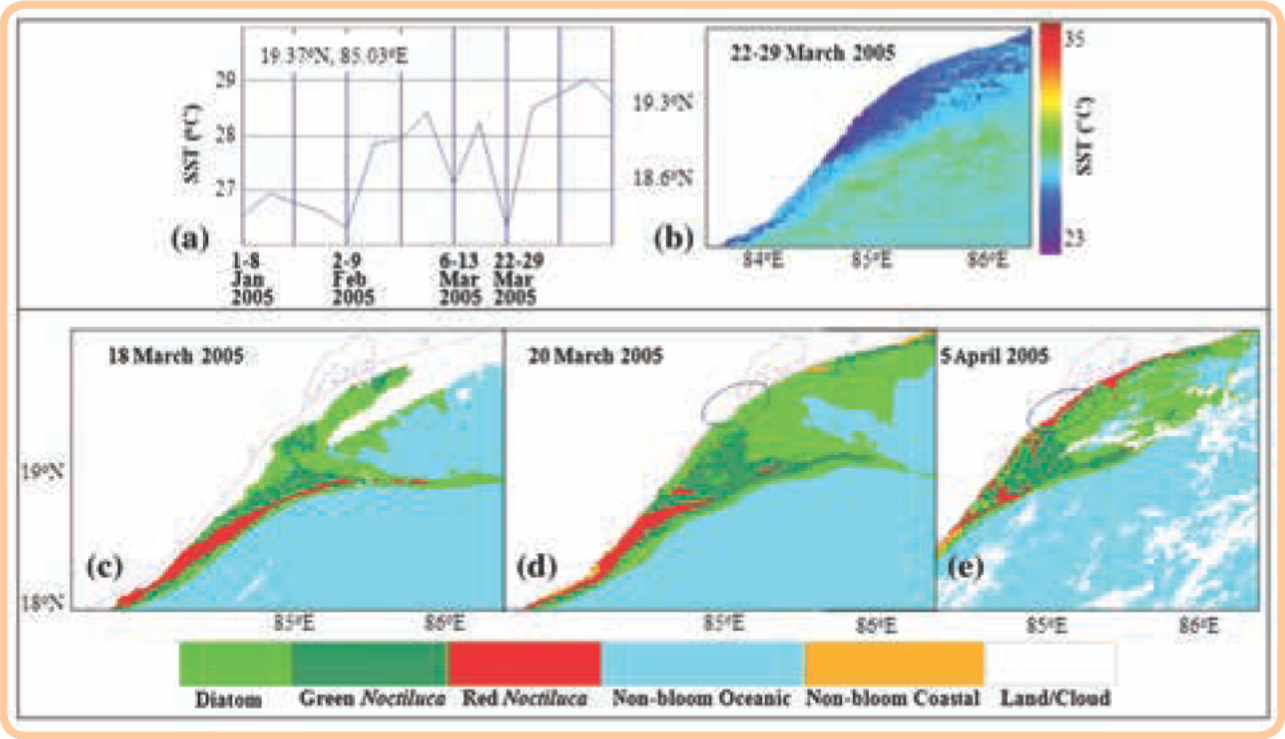


Comparison of spatially averaged time-series chlorophyll concentrations (mg m−3) derived from model simulations (respective forcings as in colour legends) with that derived from SeaWiFS and MODIS-Aqua satellite data, for NEAS, CEAS and SEAS (upper, middle and lower panels, respectively) during 2007–2009

REF: Chakraborty, K., Nimit K., Gupta, G.V.M. Getting the right wind-forcing for an ecosystem model: A case study from the eastern Arabian Sea (2017) Journal of Operational Oceanography, 10 (2), pp. 176-190.

8.12. An optical remote sensing approach for ecological monitoring of red and green *Noctiluca scintillans*

An ecosystem disruptive bloom of red *Noctiluca scintillans* (hereafter Noctiluca) was observed in coastal waters of the north-western Bay of Bengal during April 2014. Based on the principle of phytoplankton group/species specific remote sensing reflectance (Rrs), a technique of detecting green Noctiluca and diatom was developed earlier using Rrs at 443, 488, and 531 nm of Moderate Imaging Spectroradiometer-Aqua (MODIS). This was appropriately modified to detect bloom of red Noctiluca in coastal waters of the Bay of Bengal. Additional Rrs data at longer wavelengths viz. 667 and 678 nm were included in the existing algorithm, and the spectral shapes were accounted



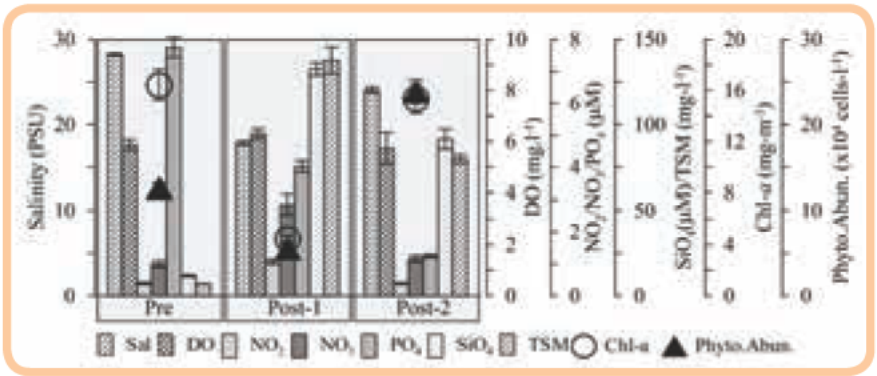
(a) MODIS retrieved 8-day rolled sea surface temperature (SST). (b) MODIS retrieved spatial map of SST. (c–e) Phytoplankton group/species image generated from MODIS of coastal waters of the north-western Bay of Bengal

REF: Baliarsingh, S.K., Dwivedi, R.M., Lotliker, A.A., Sahu, K.C., Kumar, T.S., Shenoi, S.S.C. An optical remote sensing approach for ecological monitoring of red and green Noctiluca scintillans (2017) Environmental Monitoring and Assessment, 189 (7), art. no. 330

to detect the bloom of red Noctiluca. The classification scheme discriminates red Noctiluca from the green form of the same species and diatom. Phytoplankton group/species products were generated using the modified approach and validated with the reported events of red and green Noctiluca blooms in the Indian coastal waters. It was reconfirmed that the diatom, red, and green Noctiluca co-exist in the coastal waters of the northwestern Bay of Bengal, and the phytoplankton community shift resulting in red/green Noctiluca proliferation following diatoms.

8.13. Phytoplankton assemblage in estuarine waters during the occurrence of Cyclone Phailin

Physical forcing of cyclonic phenomenon on water quality often exerts stress on marine and estuarine ecosystems due to their unpredictability. A study was carried out to decipher the phytoplankton community structure in Rushikulya estuary during the occurrence of very severe cyclone Phailin, which made landfall on 12th October 2013. A detailed analysis of surface water



Distribution of physico-chemical and biological parameters during pre and post phases of cyclone Phailin in Rushikulya estuary (Sal, Salinity; DO, Dissolved oxygen; NO_2, Nitrite; NO_3, Nitrate; PO_4, Phosphate; SiO_4, Silicate; TSM, total suspended matter; Chl-a, chlorophyll-a; Phyto. Abun., Phytoplankton abundance). The vertical lines with a cap in each bar represent standard deviation.

REF: Baliarsingh, S.K.; Srichandan, S., Lotliker, A.A., Gracia-Escobar, M.F., Tripathy, M, Sahu, K.C., Srinivasa Kumar, T., Temporal variation of phytoplankton assemblage in estuarine waters: implication of cyclone Phailin (2017) Current Science, 13(5), pp. 858-860.

samples collected from Rushikulya estuary, which is 20 km away from the landfall point of cyclone Phailin was analyzed to determine the amount of inorganic nutrients (nitrite, nitrate, phosphate and silicate), dissolved oxygen (DO), total suspended matter (TSM) and chlorophyll-a (Chl-a) during the occurrence of cyclone. The analysis revealed that instantaneous increment in nutrient concentration aftermath of cyclone Phailin did not promote phytoplankton abundance.

8.14. Impact of sea level rise and coastal slope on shoreline change along the Indian coast

Densely populated coastal zones of India are highly exposed to natural environment. These are impacted by episodic natural events, continuous coastal process, gradually rising sea levels and coexisting human interventions. The implication of the sea level rise and coastal slope in the coastal erosion for entire mainland of India were assessed based on satellite-derived Shoreline Change Rate using the Landsat TM and ETM+ acquired during 1989–2001 and the Shoreline Change Rate (SCR) derived by Bruun Rule using the parameters such as coastal slope and sea level trend derived from satellite altimetry. Satellite-derived SCR compared well with the shoreline change estimated based on Bruun Rule. Peaks of shoreline retreat calculated using Bruun model and satellite-observed SCR offset by 25–50 km. Offset in these peaks was observed due to net drift towards north in the east coast and south in the west coast of India. This study demonstrated that coastal slope is an additional parameter responsible for the movement of shoreline along with sea level change. The results of satellite-derived SCR revealed that the highest percentage of erosion is along West Bengal coast with 70% followed by Kerala (65%), Gujarat (60%) and Odisha (50%). The coastlines of remaining states recorded less than 50% of coasts under erosion. Results of this study are proving critical inputs for the coastal management.

Figure 1: Spatial distribution of shoreline change rate and SOI tide gauge station (asterisk mark) along the Indian mainland coast (negative sign indicates the erosion, and positive sign accretion)

REF: Mohanty, P.C, Mahendra, R. S., Nayak, R. K., Srinivasa, Kumar, T., Impact of sea level rise and coastal slope on shoreline change along the Indian coast (2017) Natural Hazards, 89(3), pp. 1227-1238.

8.15. An Ephemeral Dinoflagellate Bloom during Summer Season in Nearshore Water of Puri, East Coast of India

An unusual occurrence of pinkish-red discoloration of the nearshore water of Puri, Odisha was reported on 12th May 2016. This event created panic among the public and authorities as Puri city is a major tourist and pilgrimage place on the east coast of India. Field observations were carried out in order to provide a scientific basis to the event and to elicit possible causes of this

discolouration. Taxonomic analysis of the phytoplankton samples revealed the dominance of red coloured dinoflagellate species *Gonyaulax polygramma*, contributing 90% to total phytoplankton population. The localized concentration of *G. polygramma* was responsible for the pinkish-red discolouration of nearshore water. The exact factor that lay behind the genesis of this bloom could not be delineated due to the short period of its persistence. But two factors - upwelling and anthropogenic nutrient influx - can be viewed as the main cause for this ephemeral bloom. Non-hypoxic conditions in the coastal water following the ephemeral bloom event indicated no significant risk of ecological deterioration to the ambient medium.

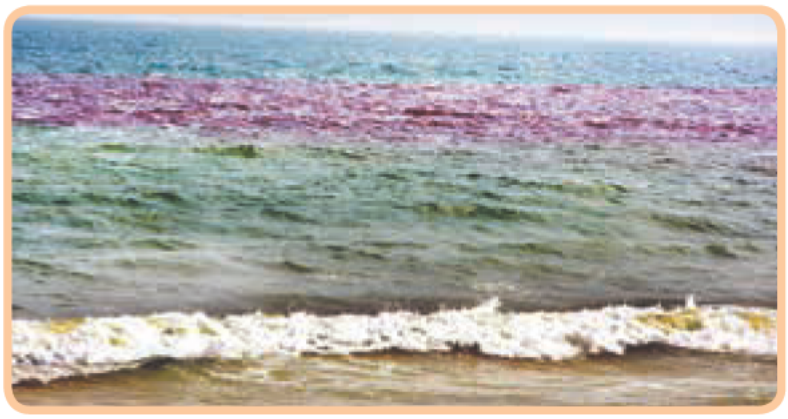


Figure 2: A photograph showing the discolouration of nearshore water of Puri, east coast of India.

REF: Baliarsingh, S.K., Dwivedi, R., Lotliker, A.A., Jayashankar, R., Sahu, B.K., Srichandan, S., Samanta, A., Parida, C., Srinivasakumar, T., Sahu, K.C. An ephemeral dinoflagellate bloom during summer season in nearshore water of Puri, east coast of India (2018) Ocean Science Journal, 53(1), pp. 143-147.

8.16. List of Publications

1. Akhand, A., Chanda, A., Dutta, S., Manna, S., Giri, S., Das, S., Mukhopadhyay, A., Lotliker, A.A., Chakraborty, K., Sarkar, N.S., Sanyal, P., Hazra, S., Choudhury, S.B., Rao, K.H. Microphytoplankton species assemblages, species-specific carbon stock and nutrient stoichiometry in the shallow continental shelf of the northern Bay of Bengal during winter (2017) Indian Journal of Geo-Marine Sciences, 46 (9) pp. 1827-1835.
2. Baliarsingh, S.K., Dwivedi, R., Lotliker, A.A., Jayashankar, R., Sahu, B.K., Srichandan, S., Samanta, A., Parida, C., Srinivasakumar, T., Sahu, K.C. An ephemeral dinoflagellate bloom during summer season in nearshore water of Puri, east coast of India (2018) Ocean Science Journal, 53(1), pp. 143-147.
3. Baliarsingh, S.K., Dwivedi, R.M., Lotliker, A.A., Sahu, K.C., Kumar, T.S., Shenoi, S.S.C. An optical remote sensing approach for ecological monitoring of red and green Noctiluca scintillans (2017) Environmental Monitoring and Assessment, 189 (7), art. no. 330
4. Baliarsingh, S.K., Lotliker, A.A., Sudheesh, V., Samanta, A., Das, Sourav, Vijayan, A.K., Response of phytoplankton community and size classes to green Noctiluca bloom in the northern Arabian Sea, (2018) Marine Pollution Bulletin, 129 (1), pp. 222-230.
5. Baliarsingh, S.K.; Srichandan, S., Lotliker, A.A., Gracia-Escobar, M.F., Tripathy, M, Sahu, K.C., Srinivasa Kumar, T., Temporal variation of phytoplankton assemblage in estuarine waters: implication of cyclone Phailin (2017) Current Science, 13(5), pp. 858-860.
6. Chakraborty, K., Nimit, K., Gupta, G.V.M. Getting the right wind-forcing for an ecosystem model: A case study from the eastern Arabian Sea (2017) Journal of Operational Oceanography, 10 (2), pp. 176-190.
7. Chatterjee, A., D. Shankar, J. P. McCreary, P. N. Vinayachandran, and A.

Mukherjee (2017), Dynamics of Andaman Sea circulation and its role in connecting the equatorial Indian Ocean to the Bay of Bengal, Journal of Geophysical Research Oceans, 122 (4), pp. 3200-3218.

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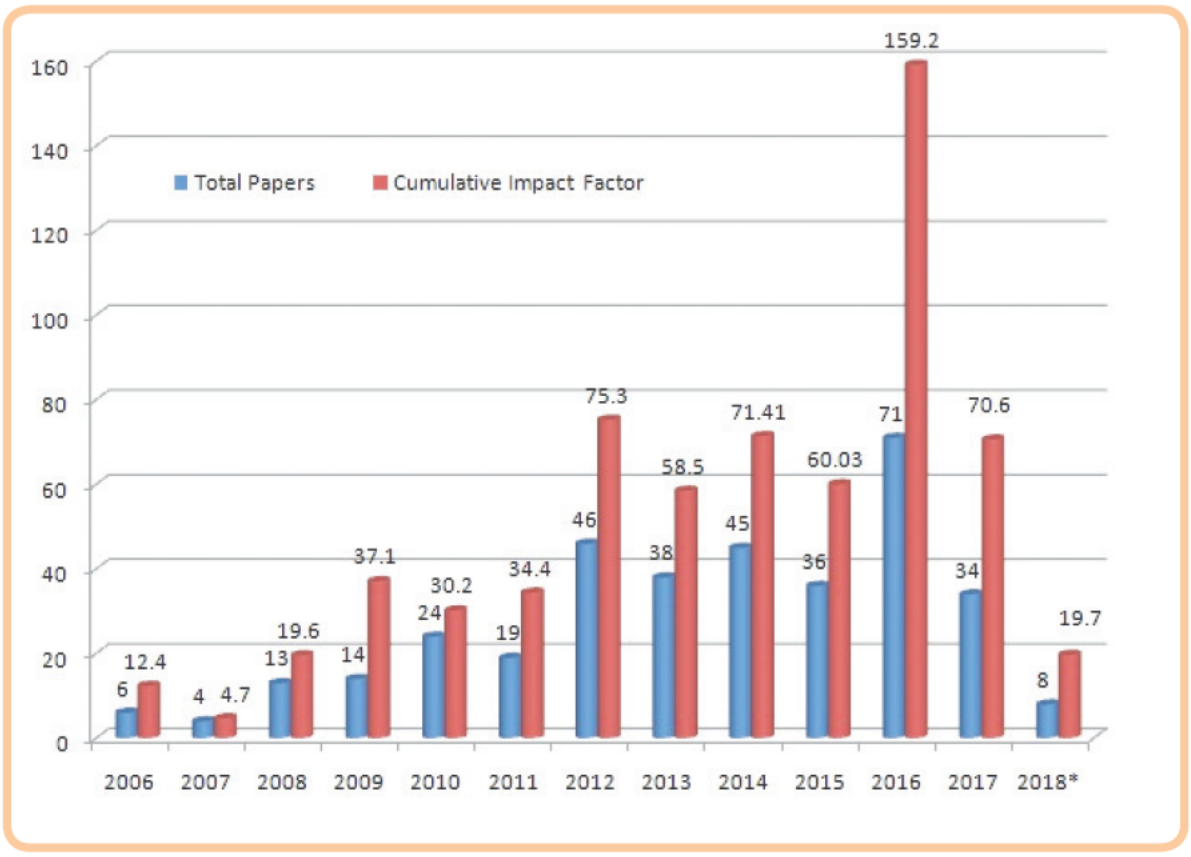


Year-wise Number of publications from INCOIS and their cumulative impact factors.

9. Capacity Building Training and Outreach

9.1. ITCOocean recognized as Category-2 Centre by UNESCO

The General Assembly of UNESCO held in November 2017 recognized the International Training Centre for Operational Oceanography (ITCOocean) of INCOIS, as a Category-2 Centre (C2C) for providing advanced training in operational oceanography to its member countries. Union Cabinet chaired by Prime Minister met on 15 December 2017 and granted permission to sign an agreement with UNESCO to establish the International Training Centre for Operational Oceanography (ITCOocean), as a Category-2 Centre (C2C) of UNESCO, at INCOIS, Hyderabad.

9.2. MoU Signed between INCOIS and KUFOS

During the signing of MoU between INCOIS and KUFOS on 2 June 2017

A Memorandum of Understanding was signed between the Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi and INCOIS) on 2 June 2017 for long term collaboration in Education and Research. The MoU was signed by Dr. Victor Joseph, Registrar, KUFOS and Dr. Satheesh Shenoi, Director, INCOIS in the presence of Prof. A. Ramachandran, Vice Chancellor, KUFOS. Subsequently, a joint research centre was setup in KUFOS campus for increased academic and research collaborations. KUFOS granted guideship for 8 scientists of INCOIS who are attached to the Joint KUFOS-INCOIS Research Centre and 3 research scholars of INCOIS have registered for their Ph.D. degree in KUFOS in the academic year 2017-18.

9.3. Training programmes conducted by ITCOocean

9.3.1. A training course on *"Seaglider Fundamentals and Data Analysis"* under Ocean Mixing and Monsoon (OMM) programme was held during 18-21 July, 2017. Prof. Craig Lee and Dr. James Bennet, Applied Physics Laboratory, University of Washington, USA were faculty for the course. Eleven participants from Indian institutions attended the training.

9.3.2. The Ocean Teacher Global Academy-INCOIS Training Course on *"GIS Applications for Coastal Zone Management"* was held during 28 August-1 September 2017. The focus of the training programme was to provide an overview as well as hands-on experience with regard to use of GIS applications pertaining to oceanography and coastal management. Topics included data acquisition, processing, analysis and interpretation of spatial data and generation of specific thematic inputs for marine and coastal programmes. Thirty - three participants from India, Bangladesh, Kenya, Mozambique, Vietnam, Indonesia, Seychelles, Sri Lanka, Thailand attended the training programme. INCOIS faculty conducted the course.

9.3.3. A Training programme on *"Remote Sensing of Marine Phytoplankton - optics, pigment and taxonomy"* was held during 19-23 March, 2018. The course provided an overview of marine phytoplankton, including its distribution in the global ocean, physical control, ecology, pigment composition etc. and its ecological relevance using remote sensing techniques. In addition, the basics of marine optics and ocean colour remote sensing were also covered with an aim to make a study at synoptic scale. Over 20 students from several national-level institutes participated. Faculty from NRSC (ISRO) and INCOIS conducted the course.

9.4. Lectures and Seminars

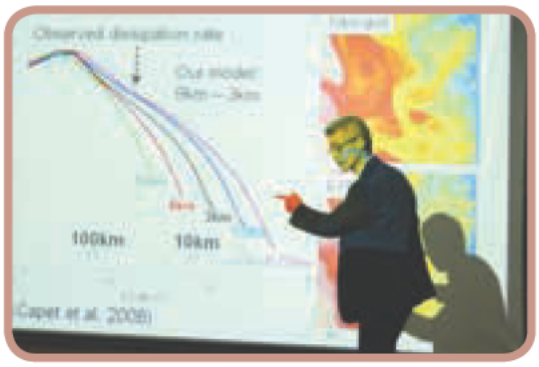
Prof. Eric A. D'Asaro, Applied Physics Laboratory and School of Oceanography, University of Washington, Seattle, USA delivered a talk on "Monsoon Intra-annual Oscillations and the formation of the Halocline in the Bay of Bengal" at INCOIS on 18 December 2017.

Dr. Vamsi Chalamalla, Postdoctoral Research Associate, University of North

Carolina Chapel Hill, USA gave a talk on "Multi-scale modelling of turbulent stratified oceanic flows" on 17 January 2018.

Prof. Sulochana Gadgil, delivered the R. Ramanathan Medal lecture titled "Homage to D R Sikka: Is the monsoon a gigantic land-sea breeze?")" on 19 February 2018. Prof. Sulochana Gadgil was honoured on this occasion with the INSA Kalpathi Ramakrishna Ramanathan Medal.

Dr. Yasumasa Miyazawa, Application Laboratory, Japan Agency for Marine-Earth Science and Technology, Japan delivered a lecture on "Development of data assimilation techniques toward resolving smaller scale oceanic phenomena in Japan Coastal Ocean Predictability Experiment (JCOPE)" on 27 February 2018.



Dr. John Siddorn (Head, Marine Forecast Research Division, Met Office, Exeter, UK), delivered a lecture "An overview of ocean forecasting activities of Met Office.

10. International Interface

10.1. IOGOOS (Indian Ocean-Global Ocean Observation System) Secretariat

The Indian Ocean Global Ocean Observing System (IOGOOS) is a regional alliance, which plays a key role in planning and sustaining ocean observations as part of the Global Ocean Observing System (GOOS). Currently, about 29 organizations from 17 countries are members of IOGOOS. The IOGOOS secretariat hosted at INCOIS is responsible for the coordination its activities. Shri M. Nagaraja Kumar, Scientist-E, ISG serves as the Secretary of IOGOOS.

The fourteenth annual meeting of IOGOOS was held in Jakarta, Indonesia under the theme of "International Indian Ocean Science Conference – 2018" during March 18 – 23, 2018. The meeting was held in conjunction with its allied projects, Indian Ocean Panel (IOP), Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER), Indian Ocean Observing System (IndOOS) Resources Forum (IRF) and International Indian Ocean Expedition (IIOE-2) Steering Committee meetings. Dr. S.S.C. Shenoi, Director, INCOIS has been elected as the chair of IOGOOS. The annual general body was updated with the progress of the activities of IOGOOS and it was informed that the IOGOOS Chair will be taking up the role of vice chair of GOOS Regional Forum from 2018 onwards. IOGOOS Secretariat, through the sponsorship funds provided by IOC/UNESCO, supported the participation of 8 delegates in the integrated meetings of IOGOOS, IOP, SIBER, IRF and IIOE-2 SC.

10.2. International Oceanographic Data Exchange

The programme "International Oceanographic Data and Information Exchange" (IODE) of the "Intergovernmental Oceanographic Commission" (IOC) of UNESCO was set up in 1961 to enhance marine research, exploitation and development, by facilitating the exchange of oceanographic data and information between participating member states. IODE designated ESSO-INCOIS as the responsible National Oceanographic Data Centre (NODC) for India, a structural element of IODE in 2004. Shri E. Pattabhi Rama Rao serves as the National Coordinator from India for 'Data Management' under the IODE Programme. He also serves on the Steering Groups on Ocean Biogeographic Information System (SG-OBIS) and IODE Quality Management Framework (SG-IODE QMF).

10.3. OceanSITES

OceanSITES is a global time series programme which is a recognized component of the Global Ocean Observing System and part of the international JCOMM. Considering its key role in the Indian Ocean region, INCOIS has been identified as the OceanSITES Data Assembly Centre (DAC). Shri E. Pattabhi Rama Rao represents ESSO-INCOIS on the OceanSITES Data Management Team. The OceanSITES Data Management Team has developed the data management system with appropriate standards, formats and quality control for the time series data from ocean.

10.4. Partnership for Observation of the Global Oceans (POGO)

POGO is a forum that was created in 1999 by directors and leaders of major oceanographic institutions around the world to promote global oceanography, particularly the implementation of an international and integrated global ocean observing system. INCOIS continued to extend its support to POGO, representing India.

10.5. Regional Integrated Multi-Hazard Early Warning System for Asia and Africa (RIMES)

RIMES is an intergovernmental, non-profit organization registered with United Nations, aims to provide regional early warning services and to build the capacity of its Member States in end-to- end early warning of tsunamis and hydro-meteorological hazards. Third Ministerial Meeting of RIMES was held on 25 August 2017, Port Moresby, Papua New Guinea. Dr. M Rajeevan, Secretary, Ministry of Earth Sciences, Government of India, the Chair of RIMES council and Dr. Balakrishnan Nair, Head, ISG, INCOIS attended the meeting from India.

As per the MoU between MoES, Govt. of India and RIMES for providing ocean state forecast services to RIMES member countries, INCOIS extended the Ocean forecasting Services to Comoros, Madagascar, and Mozambique. Dr. M. Rajeevan, Secretary, MoES launched these services during the third ministerial meeting of RIMES in the presence of Dr. David Grimms, President of World Meteorological Organization (WMO), Mr. Wesley Nukund, Minister for Disaster Management, Papua New Guinea, Soulaimana Kaambi, Deputy Minister, Comoros, Mr. Abdullahi Majeed, Minister of Disaster Management Maldives, Anura Priyadharshana Yapa, Minister of Disaster Management Sri Lanka, Mr. Subbaiah, Director RIMES Dr. Balakrishnan Nair, Head, ISG, INCOIS and disaster management officials of 48 countries of Indian and pacific Ocean region. With this, INCOIS is now providing operational ocean forecast services to 6 Indian Ocean rim countries. The Ministerial council and the World Metrological Organization lauded and placed in records the initiatives of INCOIS/India in providing the Ocean forecast and Early warning services to Indian Ocean countries and taking a leadership in Ocean Services in the Indian Ocean region.

10.6. The Indian Ocean Observing System (IndOOS)

The Indian Ocean Observing System (IndOOS) was implemented to understand the role of the Indian Ocean in the global climate system. IndOOS data is being used to address several societal and economic needs, in weather and climate forecasting and in the production of routine ocean state maps, re-analyses and predictions. Along with US, Japan, Australia and other countries, India is a major contributor in the implementation of Indian Ocean observing systems. An IndOOS Review meeting was co-hosted by UNESCO – Intergovernmental Oceanographic Commission (IOC) Perth Programme office, Indonesian Institute of Sciences (LIPI) and Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) in Jakarta, Indonesia during 18-23 March 2018. Dr. S.S.C. Shenoi, Director, INCOIS, Dr. S. Rajan, Consultant Scientist, Shri M. Nagaraja Kumar Scientist 'E' and Dr. Satya Prakash Scientist 'E' attended the review meeting.

10.7. SIBER (Sustained Indian Ocean Biogeochemistry and Ecosystem Research) International Programme Office

The SIBER International Programme Office is being hosted at INCOIS since 2010. The office manages various activities such as organisation of annual Science Steering Committee (SSC) meetings and sharing of online updates along with management of the SIBER website. INCOIS is represented in SIBER by Dr. Satya Prakash, Scientist 'E', ISG, who also manages the programme office. The 8th annual meeting of SIBER was held during 21-22 March 2018 in Jakarta, Indonesia.

10.8. International Indian Ocean Expedition-2 (IIOE-2)

The Second International Indian Ocean Expedition (IIOE-2) was launched with the first expedition in late 2015 during the IO50 International Symposium and will continue through to 2020. It is a major global scientific initiative seeking to build on the legacy of the first international Indian Ocean expedition IIOE (1957-65). IIOE-2 is co-sponsored by Intergovernmental Oceanographic Commission (IOC), the Scientific Committee on Oceanic Research (SCOR) and the Indian Ocean Global Observing System (IOGOOS), with ESSO- INCOIS spearheading Indian activities. Several international collaborative research programmes and outreach activities within the framework of a comprehensive Science Plan are proposed to be initiated under IIOE-2. IIOE-2 activities are focused towards helping to build research capacity in the Indian Ocean rim countries and in motivating efforts to make the oceanographic data from the region more widely accessible to the scientific fraternity. Dr. Satheesh Shenoi, Director, INCOIS serves as one of three co-chairs of the IIOE-2 Steering Committee. A Joint Programme Office (JPO) of IIOE-2 is hosted at INCOIS to coordinate the plan the activities of this international expeditions. Dr. S. Rajan served as the coordinator of the JPO-India. The Australian node of JPO is hosted at IOC, Perth Office.

A half-yearly newsletter "The Indian Ocean Bubble-2" is being published by INCOIS on behalf of the IIOE-2 National Committee. The main objective of this newsletter is to encourage informal exchange of ideas between scientists having a sustained interest in studies of the Indian Ocean. A monthly newsletter is also being published to provide regular updates of the programme activities (http://iioe-2.incois.gov.in). The 2nd meeting of the Steering Committee (SC) of IIOE-2 was held in Jakarta, Indonesia during 18-21 March 2018. Dr. S. S. C. Shenoi, Director, INCOIS, S. Rajan and Satya Prakash attended the meeting.

A workshop on Data & Information management was also organised to discuss and formulate data management and sharing policy for data collected during the IIOE-2 expedition along with the 2nd IIOE-2 steering committee meetings during 21-23 March 2018. Shri Pattabhi Rama Rao, Scientist 'F' and Head, Data Management Group and Shri. R. Venkat Seshu from INCOIS served as the resource persons in the workshop.

10.9. GODAE Ocean View

GODAE Ocean View is a group of scientists representing agencies which provide operational ocean forecasts and manage in situ and remote sensing observation platforms. This forum provides an excellent platform for the scientists to exchange their experiences on ocean

modelling and data assimilation and collectively carry out inter-comparison exercises of various ocean forecast and analysis products. INCOIS has been part of this group since October 2010 as a member of the science team. Director, INCOIS serves as a member of GODAE Ocean View Patrons' Group, which is responsible for guiding the GODAE Ocean View science teams to attain various targets and for supporting the project office established in the UK Met Office. The eighth annual meeting of the GODAE Ocean View Science Team (GOVST) was held during 6-10 November 2017 in Bergen, Norway. Dr. Abhisek Chatterjee, Scientist 'D', who is the national system representative attended this meeting.

10.10. Union Commission on Data and Information (UCDI)

In 2008, IUGG established the Union Commission on Data and Information (hereafter UCDI), an entity to deal with data and information issues at the Union level and engage with similar bodies in other Unions and Societies. The objective of UCDI is to enable a high level of cooperation within and between scientific communities. This cooperation is needed in order to ensure the availability of modern data and information systems and services, which are globally distributed, provide universal open access, and are sustainable. In 2017, President of IUGG appointed Dr. S.S.C. Shenoi, Director, INCOIS as the chair of UCDI for a period of 3 years.

11. General Information

11.1. ESSO-INCOIS Foundation Day

The 19th Foundation Day of ESSO-INCOIS was celebrated with a two-day Open House Programme (2-3 February 2018) which included a tour and audio-visual aided interactions with scientists regarding different types of ocean information services and different technologies used. Over 720 school and college students and faculty participated. The Foundation Day Lecture was delivered by Hon'ble Vice Chancellor, University of Hyderabad, Prof. Appa Rao Podile on the theme "Metagenomics of Oceans and Earth in the Big Data Era" detailing the development of genomics, its various milestones, benefits to society and future potential.

11.2. Awards and Honours

11.2.1. Ministry of Earth Sciences Awards

Dr. Aneesh Lotliker, Scientist D & In- charge, Ocean Colour Applications was awarded *Certificate of Merit-2017* and Ms. Rakhi Kumari, Scientific Assistant-B, was awarded the Best *Employee Award-2017*. They received the awards during the 11th Foundation Day Function of Ministry of Earth Sciences held at Vigyan Bhawan, New Delhi on 27 July 2017.

11.2.2. Associate of the Indian Academy of Sciences

Dr. Praveen B. Kumar, Scientist D, was elected as Associate of the Indian Academy of Sciences. The

Associateship is tenable for a maximum period of 5 years till the age of 35 or a minimum period of 3 years.

11.2.3. Special Jury Award for "The Indian Ocean Bubble-2"

The 6th issue of "The Indian Ocean Bubble-2", the international informal half-yearly newsletter that encourages brainstorming and discussion among Indian Ocean oceanographers (published by ESSO-INCOIS on behalf of the National Organizing Committee - International Indian Ocean Expedition-2, India) was awarded the Special Jury Prize under the category "Best Cover Design" by Public Relations Society of India, Hyderabad Chapter during the "2nd Telangana State Public Relations Conference" held on 6 August 2017 at Hyderabad.

11.2.4. Best Paper Award at SAFARI-2

Dr. Aneesh Lotliker was awarded with the Best Paper Award during 'SAFARI 2' International Symposium on Remote Sensing for Ecosystem Analysis and Fisheries hosted by ICAR-Central Marine Fisheries Research Institute (CMFRI), Kochi, during 15-17 January 2018.

11.3. Promotion of Hindi

The Official Language Implementation Committee, INCOIS organized several programmes to promote the usage of Hindi effectively in day-to-day work. Potential Fishing Zone Advisories and Ocean State Forecasts were continued to be issued in Hindi along with local Languages. Three seminars were organised during 2017-18.

- "Official Language Policy" by Shri. Shivanand Kalekar, Hindi Professor, Hindi Teaching Scheme (HTS), Hyderabad on 15 March 2018.
- "Annual Programme for the use of Hindi for the year 2017-18" by Shri. Ravi Ranjan, Rajbhasha Assistant, Official Language Department, Insurance Regulatory and Development Authority of India (IRDAI), Hyderabad on 22 November 2017.
- "Present Reference of Official Language Implementation" Dr. M. Venkateshwar, Former Professor & Head, Department of Hindi & India Studies, the English and Foreign Languages University (EFLU), Hyderabad on 30 June 2017.

Shri. Kalekar, HTS *Shri. Ranjan, IRDAI* *Dr. Venkateshwar, EFLU*

A Hindi Pakhwara programme was organized during 1-14 September 2017 to promote Hindi usage. The programme included competitions on essay writing, quiz competition, poem recitation etc. for the staff of INCOIS and a special elocution competition for children of the staff of INCOIS. As part of the celebration, a special event was also organised on 8 September 2017 which included lectures by Dr. V. M. Tiwari, Director, CSIR-NGRI, Hyderabad & Chairman, Town Official Language Implementation Committee (TOLIC-3) and Dr. D. D. Ozha, Senior Scientist, Hindi Advisory Committee, Government of India. Winners of Hindi Essay, Elocution, Extempore and Presentation competitions were felicitated at the event.

11.4. Swachh Bharat Mission Initiative

As part of the National Swachh Bharat Mission, several activities were organised by INCOIS to spread the message of cleanliness to both staff and public. Swachhta Pakhwara was organised during 16-30 June, 2017. The Pakhwara was inaugurated with a lecture 'Awareness about Cleanliness' by the Medical and Health Officer Dr. K. V. Shiva Prasad of Greater Hyderabad Municipal Corporation (GHMC) followed by the screening of films on cleanliness, essay and quiz competitions for Zilla Parishad School students from Gajularamaram and Pragathi Nagar. Pakhwara activities included a cleanliness drive on the INCOIS entry road, an Awareness Walk from

INCOIS to Pragathi Nagar, cleaning of the Zilla Parishad School, Pragathi Nagar, etc. During 15 September- 2 October 2017, a Swachhta Hi Seva drive was conducted that included staff taking the Swachhta Pakhwara Pledge, cleaning of surrounding areas and plantation of trees.

11.5 Installation of Rooftop Solar Power Plant

INCOIS installed a 396.80kWp capacity roof top solar power plant on the existing buildings. The plant was commissioned by Dr. M Rajeevan, Secretary MoES on 18 August 2017. One thousand two hundred and forty (1240) solar panels with 320 Wp capacity are used to cover an approximate roof top area of about 30000 sqft. Estimated power generation per year from this plant is 600755 kWh, which will be equal to 20% of annual power consumption of INCOIS. The tariff for solar generated power is fixed at Rs.4.85/kWh for a period of 25 years.

11.6. Vigilance and RTI Activities

B V Satyanarayana, Scientist 'G' & Head, CWG continued to serve as Vigilance Officer at INCOIS. Five complaints have been received during April 2017 to March 2018. Upon verification, as per CVC guidelines, it was found that all the five complaints were pseudonymous and hence no further investigation was carried out. The same has been reported to CVO, MoES. "Vigilance Awareness Week" was observed at ESSO-INCOIS during 30 October - 4 November 2017. A guest lecture by Hon'ble Justice G V Seethapathy, Retired Judge, High Court, Hyderabad was arranged on 1 November 2017. INCOIS staff took the Vigilance Pledge on 30 October 2017. In respect to the Right to Information Act (RTI) 2005, queries related to INCOIS were regularly updated on the INCOIS website in prescribed format. E. Pattabhi Rama Rao, Scientist E & Head, ODG & TWG is the Public Information officer and S.S.C. Shenoi, Director, INCOIS is the First Appellate authority. In this period 14 RTI applications and 2 First Appeals were received. Replies were provided for all applications and appeals.

11.7. Public Outreach and Awareness Activity

To increase awareness a bout INCOIS ' products and services, special Open Day Programmes were organized including a weeklong open house and poster exhibition to celebrate MoES Foundation Day (27 July 2017), two -day programmes for the

Tsunami World Awareness Day (5-6 November 2017) and INCOIS Foundation Day (2-3 February 2018). On request, group visit sessions were also organised for several schools and colleges. INCOIS also organised visits for government officials. More than 4100 persons including 402 national and international government officials made field visits to INCOIS during 2017-18.

11.8. Academic projects carried out by students in INCOIS

Sl. No	Name of Student	Institute	Project Guide
1.	Abin George	Kerala University of Fisheries and Ocean	Srinivasa Rao N.
2.	Agnus Mathews	Central University of Karnataka	Prakash Mohanty
3.	Akarapu Akhil	Rajiv Gandhi University of Knowledge	Venkat Reddy M.
4.	Alisha Khan	Amity University. Noida	Srinivasa Rao N.
5.	Aman Pathak	Amity University, Noida	Srinivasa Rao N.
6.	Anagha V. Devan	Sree Krishna College, Kerala	Harikumar R.
7.	Anusha Chitwadgi	Central University of Karnataka	Mahendra R. S.
8.	Asha P. Nair	Sree Krishna College, Kerala	Harikumar R.
9.	Ashin Kuriakose	Cochin University of Science and	Girishkumar M.S.
10.	Athira K.	Sree Krishna College, Kerala	Harikumar R.
11.	Mounika B.	Sphoorthy Engineering College, Hyderabad	Kiran kumar N.
12.	Vijay Kumar B.	Vignana Bharathi Institute of Technology (VBIT)	Kaviyazhahu K.
13.	Batthini Venkatesh	Rajiv Gandhi University of Knowledge	Kaviyazhahu K.
14.	Bijit Kumar Kalita	University of Hyderabad	Arnab Mukherjee
15.	Nandhini D.	Indian Academy of Sciences, Bangalore	Suprit Kumar
16.	Deepak Gottapu	Indian Academy of Sciences, Bangalore	Kunal Chakraborty
17.	Dinesh Chandra	Indian Institute of Technology Kharagpur	Sudheer Joseph
18.	Jimna Janardhan C. M.	Cochin University of Science and Technology (CUSAT), Kochi	Remya P. G.
19.	Gyaneshwari K.	Andhra University	Srinivasa Rao N.
20.	Saisindhu K.	Andhra University	Ajay Kumar B.
21.	Shailesh K.	National Institute of Technology Karnataka	Murty P. L. N.
22.	Soundarya K.	GITAM University, Visakhapatnam	Satyanarayana B.V.S.
23.	Kavya Rajagopal	Cochin University of Science and Technology (CUSAT), Kochi	Francis P. A.
24.	Kribashini N.	Anna University	Srinivasa Rao N.
25.	Krishnavishek Pati	Manipal University, Manipal	Aneesh A. Lotliker
26.	Madhuri Kalaskar	Central University of Karnataka	Mahendra R. S.
27.	Manne Pandu	Jawaharlal Nehru Technological University (JNTU) Hyderabad	Sourav Maity

28.	Harshita N. V.	Sreenidhi Institute of Science and Technology (SNIT) Hyderabad	Ramakrishna P. Phani
29.	Naazneen J.	Anna University	Sourav Maity
30.	Neeraj Benny	Indian Academy of Sciences, Bangalore	Kunal Chakraborty
31.	Jhansy P.	Andhra University	Srinivasa Rao N.
32.	Santosh P.	Vignana Bharathi Institute of Technology (VBIT) Hyderabad	Venkat Reddy M.
33.	Shrujan Reddy P.	GITAM University, Hyderabad	Arun Nherakkol
34.	Vivek P.	Jawaharlal Nehru Technological University (JNTU) Hyderabad	Venkat Shesu R.
35.	Pranav Bahulekar	University of Pune	Venkat Shesu R.
36.	Prnga Mahesh	Rajiv Gandhi University of Knowledge Technologies (RGUKT), Basar	Venkat Reddy M.
37.	Purnima Patnaik	Kumaun University	Aneesh A. Lotliker
38.	Renjini S. L.	Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi	Mahendra R. S.
39.	Rohith	Vignana Bharathi Institute of Technology (VBIT) Hyderabad	Kaviyazhahu K.
40.	Sreeraj P.	Cochin University of Science and Technology (CUSAT), Kochi	Francis P. A.
41.	Suraj Kumar	Vignana Bharathi Institute of Technology (VBIT) Hyderabad	Venkat Reddy M.
42.	Swagatika Patel	Kumaun University	Aneesh A. Lotliker
43.	Thara Anna Mathew	Indian Academy of Sciences, Bangalore	Francis P. A.
44.	Nirup Y.	Jawaharlal Nehru Technological University (JNTU) Hyderabad	Mahendra R. S.

11.9. Deputations Abroad

No	Name of the Official (Dr./Mr./Ms.)	Meeting/Conference/Training
1.	Satheesh Shenoi, Director	To attend the 11th session of Intergovernmental coordination group for the ICG/ IOTWMS XI at Kuala Lumpur, Malaysia during 18-19 April, 2017. Part of Indian Delegation attending the India - Pacific Islands Sustainable Development Conference at SUVA, Fiji during 25-26 May, 2017. To attend the 29th Session of the IOC assembly and 50th session of the IOC Executive Council at UNESCO Headquarters, Paris during 20-29 June, 2017. To participate in the meeting of the Working Group meeting on 14 July 2017 in Lisbon, Portugal to discuss the detailed plan for the establishment of the Atlantic International Research Centre (AIR Centre). To attend the 2nd Japan Agency for Marine -Earth Science and Technology (JAMSTEC), Advisory Board (JAB) meeting during 6–7 March 2018 in Japan. To attend the Meeting of the Steering Committee of IIOE-2 and the Annual Meetings of Indian Ocean Global Ocean Observing System (IOGOOS)- XIV, Indian Ocean Regional Panel (IORP), Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER) and IndOOS Ocean Resource Forum (IRF) in Jakarta, Indonesia during 19-23 March, 2018.
2.	T. M. Balakrishnan Nair, Scientist 'F' & Head, ISG	To attend 9th Regional Integrated Multi-Hazard Early Warning System (RIMES) for council meeting and 3rd RIMES Ministerial Conference at Port Moresby, Papua New Guinea during 23-25 August, 2017. To attend 1st International workshop on Waves, Storm surges and Coastal hazards, at Liverpool, UK during 9-15 September 2017. To attend 2nd High Level Industry-Science-Government Dialogue on 'Atlantic Interactions' Brazil Summit: Implementing the Atlantic International Research (AIR Center) at Florianopolis, Santa Catarina, Brazil.
3	Pattabhi Rama Rao, Scientist- F & Head-ODG & TWG	To participate in the 19th Argo Steering Team (AST-19) meeting to be held at Victoria, Canada during 12-16 March 2018. To participate in the International Indian Ocean Expedition (IIOE-2) Data & Information Management Workshop to be held at Jakarta, Indonesia during 21-23 March 2018.

4	Sudheer Joseph, Scientist-F & Head CSG	To participate in "Session-V of Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM-V)" at Geneva, Switzerland during 25-29 October, 2017. To participate in HWRF tutorial during 23-25 January, 2018 and further training on HYCOM coupled HWRF modelling system of EMC-NCEP during 26 January to 3 February, 2018 at NCEP/EMC, USA.
5	T. V. S. Udaya Bhaskar, Scientist-E & Head, TPG	To participate in the "18th Meeting of Argo Data Management Team (ADMT-18)" at Hamburg, Germany during 27 November - 2 December, 2017.
6	P. A. Francis, Scientist-E and Head, MDG	As part of India's Marine Science Mission to UK during 26 February to 1 March, 2018.
7	M. Nagaraja Kumar, Scientist 'E', ISG & Secretary, IOGOOS	To participate in the Indian Ocean Global Ocean Observing System (IOGOOS) Workshop and 14th Annual meeting held in conjunction with the meetings of Sustained Indian Ocean Bio- geochemical and Ecological Research (SIBER), IndOOS Resource Forum (IRF), Indian Ocean Panel (IOP) and International Indian Ocean Expedition (IIOE)- 2 meetings to be held at Jakarta, Indonesia during 18-23 March, 2018 .
8	Satya Prakash, Scientist 'E', ISG	To participate in the Indian Ocean Global Ocean Observing System (IOGOOS) Workshop and 14th Annual meeting held in conjunction with the meetings of Sustained Indian Ocean Bio- geochemical and Ecological Research (SIBER), IndOOS Resource Forum (IRF), Indian Ocean Panel (IOP) and International Indian Ocean Expedition (IIOE)- 2 meetings to be held at Jakarta, Indonesia during 18-23 March, 2018.
9	R. Venkat Shesu, Scientist 'D', ODG	To participate in the International Indian Ocean Expedition (IIOE -2) Data & Information Management workshop during 21-23 March, 2018 at Jakarta, Indonesia.
10	Ch. Patanjali Kumar Scientist 'D', TWG	To attend the meetings of WG on Tsunami Detection, Warning & Dissemination, Task Team on IOWave18, Standar Operating Procedure workshop, and steering group meeting of the ICG/IOTWMS of IOC-UNESCO to be held during 11-17 September, 2017 at Jakarta, Indonesia.
11.	R. S. Mahendra, Scientist 'D', TWG	To attend "Training of Trainers on Tsunami Evacuation Maps, Plans and Procedures (TEMPP)" organized by Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS) of IOC-UNESCO to be held during 13-23 November 2017 at Cetiko, Indonesia .
12.	Kunal Chakraborty Scientist 'D', MDG	Deputation to participate in the World Conference on Natural Resource Modelling at Barcelona, Spain during 5-9 June, 2017 followed by the annual meeting of SEAVIEW (an international network funded by the Belmont Forum) on 10 June, 2017 in Barcelona.

13.	M. Vijaya Sunanda, Scientist 'D', TWG	To participate in the 11th Session of the intergovernmental coordination group for the Indian ocean Tsunami warning and Mitigation system (ICG/IOTWMS-XI) scheduled at Putrajaya, Malaysia during 17-20 April, 2017. To attend training course on GPS data processing and analysis with GAMIT/ GLOBK / TRACK for tsunami early warning at UNAVCO HQ, Colorado, USA during 19-23 June, 2017. To attend meetings of Task team on "Capacity Assessment of Tsunami preparedness" and working group (WG-1) on Tsunami Risk, Community awareness and preparedness" of the ICG/IOTWMS of IOC/UNESCO to be held during 4-9 September, 2017 at Jakarta, Indonesia.
14.	J. Padmanabham Scientist 'D', TWG,	To attend the meetings of WG on Tsunami Detection, Warning & Dissemination, Task Team on IOWave18, Standard Operating Procedure workshop, and steering group meeting of the ICG/IOTWMS of IOC- UNESCO to be held during 11-16 September, 2017 at Jakarta, Indonesia.
15.	Abhisek Chatterjee, Scientist- C, MDG,	To participate in "8th meeting of the GODAE OceanView Science Team (GOVST)" at Bergen, Norway during 6-10 November, 2017. To participate in the Ocean Sciences Meeting held at Portland, USA during 11-16 February, 2018.
16.	P.L.N. Murty, Scientist 'C', ASG	To attend "6th Session of IOC Regional Committee for Central Indian Ocean (IOCINDIO-VI) during 24-25 May 2017 and IOCINDIO strategic Revitalisation scoping Workshop during 22-23 May, 2017". To attend "Workshop-Conference on Earthquakes and Tsunami: Modeling and Observations" during 11-22 December, 2017 at Hanoi, Vietnam
17.	Alakes Samanta, Scientist 'B', ISG	To attend NERC Advanced Training course on "Ocean-Colour Data in climate studies" at Plymouth Marine Laboratory, Plymouth, UK during 18 - 22 September, 2017.
18.	Arnab Mukherjee, Project Scientist 'B', MDG	To participate in the GODAE Ocean View (GOV) international School at Mallocra, Spain during 2-13 October, 2017. To participate in the Ocean Sciences Meeting followed by Ocean Mesoscale Eddy Interactions with the Atmosphere workshop during 11-18 February, 2018 at Portland, USA.
19.	K. Siva Srinivas Project Scientist - B, TWG	To attend "Workshop-Conference on Earthquakes and Tsunami: Modelling and Observations" during 11-12 December, 2017 at Hanoi, Vietnam
20.	Deep Sankar Banerjee, Project Scientist 'B', MDG	To participate in RIKEN - International School on Data Assimilation 2018 (RISDA) scheduled to be held at RIKEN Advanced Institute for Computational Sciences (AICS), Kobe, Japan during 22-26 January, 2018 .

21.	S. Rajan, Consultant and Co- ordinator, IIOE-2	To participate the IORA Indian Ocean Conference on "Marine Spatial Planning - Towards Sustainable Use of the Indian Ocean" scheduled to be held on 22-23 November, 2017 in Mauritius

11.10 INCOIS Human Capital

Category/Designation	Regular	Category/ Designation	Project Mode
Scientific Staff			
Director	1	Project Sci - D	1
Scientist 'G'	2*	Project Sci - C	2
Scientist 'F'	3*	Project Sci - B	25
Scientist 'E'	5	Project Assistant	29
Scientist 'D'	19	Admin Assistant/	
Office Assistant/ Jr. Office Asst.	6		
Scientist 'C'	13	Lab Attendants	6
Scientist 'B'	3	Driver-cum-Attendant	4
Scientific Support Staff		Consultants	2
Scientific Assistant B	18	Research Fellows under Ph.D Programme	13
Scientific Assistant A	1		
Administrative Support			
Dy.CAO	1		
Manager	1		
Jt. Manager	2		
Asst. Manager	4		
Sr. Executive	3		
Total	**77**	**Total**	**88**

* Dr. M. Ravichandran, Scientist 'G' & Dr. T. Srinivasa Kumar, Scientist 'F' are on lien.

12. Acronyms

A&N	-	Andaman & Nicobar
ADCIRC	-	Advanced Circulation (Storm surge model)
ADMT	-	Argo Data Management Team
AICS	-	Advanced Institute for Computational Sciences
AIR	-	All India Radio
ANCOST	-	Andaman and Nicobar Centre for Ocean Science and Technology
AOD	-	Aerosol Optical Depth
APPMB	-	Andhra Pradesh Port Management Board
APWD	-	Andaman Public Works Department
ARGO	-	Array for Real-time Geotropic Oceanography
ASCAT	-	Advanced Scatterometer
ASG	-	Advisory Services Group, ESSO-INCOIS
ASIMET	-	Air-Sea Interaction Meteorology
AST	-	Argo Steering Team
ATOVS	-	Advanced TIROS Operational Vertical Sounder
AVHRR	-	Advanced Very High-Resolution Radiometer
AWS	-	Automated Weather Stations
BB	-	Bay of Bengal
BGC	-	Biogeochemical
BMKG	-	Badan Meteorologi, Klimatologi, dan Geofisika- Indonesian Agency for Meteorology, Climatology and Geophysics
BoB	-	Bay of Bengal
C2C	-	Category-2 Centre
CAO	-	Central Administrative Officer
CC	-	chlorophyll concentration
CDOM	-	Chromophoric dissolved organic matter
Chl-a	-	Chlorophyll-a
CMFRI	-	Central Marine Fisheries Research Institute
CMIP	-	Coupled Model Intercomparison Project
CMLRE	-	Centre for Marine Living Resources & Ecology, Kochi
COBALT	-	Carbon, Ocean Biogeochemistry and Lower Trophics model
COMAPS	-	Coastal Ocean Monitoring and Prediction System
COMMs	-	Communications Test
CPUE	-	Catch Per Unit Effort

CRSs	-	Central Receiving Stations
CSG	-	Ocean-Atmosphere Coupled System Group
CSIR	-	Council of Scientific & Industrial Research
CTD	-	Conductivity-Temperature-Depth
CUSAT	-	Cochin University of Science and Technology
CVC	-	Central Vigilance Commission
CVO	-	Central Vigilance Officer
CWG	-	Computational Facilities, Communications Network and Web Services Group
DA	-	Data Assimilation
DAC	-	Data Assembly Centre
DDS	-	Digital Display Systems
DINEOF	-	Data Interpolation Empirical Orthogonal Functions
DO	-	Dissolved Oxygen
EDBs	-	Electronic Display Boards
EEZ	-	Exclusive Economic Zone
EFLU	-	English and Foreign Languages University
EIA	-	Environmental Impact Assessment
EKWs	-	Equatorial Kelvin Waves
ENSO-IOD	-	El Nino Southern Oscillation- Indian Ocean Dipole
EOA	-	Eastern Offshore Asset
EOF	-	Empirical Orthogonal Function
EQ	-	Earth Quake
ERP	-	Enterprise Resource Planning
ESSO	-	Earth System Science Organisation
ETM	-	Landsat Enhanced Thematic Mapper
FAX	-	Facsimile
FORV	-	Fisheries Ocean Research Vessel
FSI	-	Fishery Survey of India
FTP	-	File Transfer Protocol
FY	-	Financial Year
GCMD	-	Global Change Master Directory
GHG	-	Green House Gases
GHMC	-	Greater Hyderabad Municipal Corporation
GIS	-	Geographic Information System
GNSS	-	Global Navigation Satellite System
GODAE	-	Global Ocean Data Assimilation Experiment

GODAS	-	Global Ocean Data Assimilation System
GOOS	-	Global Ocean Observation System
GOVST	-	GODAE Ocean View Science Team
GPRS	-	General Packet Radio Service
GPS	-	Global Positioning System
GSI	-	Geological Survey of India
GTS	-	Global Telecommunication System
GUI	-	Graphic User Interface
HADR	-	Humanitarian Assistance and Disaster Relief
HF RADAR	-	High Frequency Radar
HOOFS	-	High Resolution Operational Ocean Re-Analysis and Forecast System
HPC	-	High Performance Computer
HQ	-	Head Quarters
Hs/Tp -	-	significant wave height/ peak wave period
HTS	-	Hindi Teaching Scheme
HWRF	-	Hurricane Weather Research and Forecast
HYCOM	-	Hybrid Coordinate Ocean Model
ICG	-	Intergovernmental Coordination Group
ICMAM	-	Integrated Coastal and Marine Area Management
ICOADS	-	International Comprehensive Ocean- Atmosphere dataset
IDS	-	Integrated Information Dissemination System
IIOE-2	-	International Indian Ocean Expedition-2
IISc	-	Indian Institute of Science, Bangalore
IIT	-	Indian Institute of Technology
IMD	-	Indian Meteorological Department
INCOIS	-	Indian National Centre for Ocean Information Services
IndOOS	-	Indian Ocean Observing System
INSA	-	Indian National Science Academy
INSAT	-	Indian National Satellite System
IO	-	Indian Ocean
IOC	-	Intergovernmental Oceanographic Commission
IOCINDIO	-	IOC Regional Committee for the Central Indian Ocean
IOD	-	Indian Ocean Dipole
IODE	-	International Oceanographic Data and Information Exchange
IOGOOS	-	Indian Ocean Global Ocean Observing System
IOM	-	Indian Ocean Model
IOP	-	Inherent Optical Properties

IORA	-	Indian-Ocean Rim Association
IORP	-	Indian Ocean Regional Panel
IOTWMS	-	Indian Ocean Tsunami Warning and Mitigation System
IOTWS WG	-	Indian Ocean Tsunami Warning System Working Group
IOWave18	-	IOTWS Indian Ocean Tsunami Exercise 2018
IPCC	-	The Intergovernmental Panel on Climate Change
IPFZ	-	Integrated Potential Fishing Zone
IRDAI	-	Insurance Regulatory and Development Authority of India
IRF	-	IndOOS Resources Forum
ISG	-	Ocean Information and Forecast Services Group, ESSO-INCOIS
ISGN	-	Indian Seismic and GNSS Network
ISRO	-	Indian Space Research Organisation
ITCOocean	-	International Training Centre for Operational Oceanography, ESSO-INCOIS
ITEWC	-	Indian Tsunami Early Warning Centre
IUGG	-	International Union of Geodesy and Geophysics
IV	-	Inland Vessel
IVL	-	Inland Vessel Limits
IVRS	-	Interactive Voice Response System
JAB	-	JAMSTEC Advisory Board
JAMSTEC	-	Japan Agency for Marine-Earth Science and Technology
JCOMM	-	Joint Technical Commission for Oceanography and Marine Meteorology
JCOPE	-	Japan Coastal Ocean Predictability Experiment
JNPT	-	Jawaharlal Nehru Port Trust
JNTU	-	Jawaharlal Nehru Technological University
JPO	-	Joint Programme Office
KG	-	Krishna-Godavari
KRC	-	Knowledge Resource Centre
KUFOS	-	Kerala University of Fisheries and Ocean Studies
LETKF-ROMS	-	Local Ensemble Transform Kalman Filter
LIPI	-	Lembaga ImuPengetahuan Indonesia- Indonesian Institute of Sciences
MaMeAT	-	Marine Meteorological Atlas
MDG	-	Ocean Modeling and Data Assimilation Group (MDG)
MEA	-	Ministry of External Affairs
Met	-	Meteorological
MFAS	-	Marine Fishing Advisory Services
MHA	-	Ministry of Home Affairs

MISO	-	Monsoon Intraseasonal Oscillation
MLDB	-	Mixed Layer Depth Budget
MJO	-	Madden-Julian Oscillation
MLT	-	Mixed Layer Temperature
MODISA	-	Moderate Imaging Spectroradiometer-Aqua
MODIS	-	Moderate Resolution Imaging Spectroradiometer
MoES	-	Ministry of Earth Sciences
MOM	-	Modular Ocean Model
MOSAIC	-	Marine Observation System Along Indian Coast
MoU	-	Memorandum of Understanding
MSSRF	-	M S Swaminathan Research Foundation
NavIC	-	NAVigation with Indian Constellation)
NCAOR	-	National Centre for Antarctic and Ocean Research
NCCR	-	National Centre for Coastal Research
NCEP/EMC	-	National Centers for Environmental Prediction /Environmental Modeling Center
NCESS	-	National Centre for Earth Science Studies
NCMRWF	-	National Centre for Medium Range Weather Forecasting
NCS	-	National Centre for Seismology, New Delhi
NDBC	-	National Data Buoy Center
NDBP	-	National Data Buoy Programme
NDMA	-	National Disaster Management Authority
NDVI	-	Normalized Difference Vegetation Index
NERC	-	Natural Environment Research Council
NetCDF	-	Network Common Data Form
NGO	-	Non-Governmental Organisation
NGRI	-	National Geophysical Research Institute, Hyderabad
NIO	-	National Institute of Oceanography, Panaji
NIOT	-	National Institute of Ocean Technology, Chennai
NITI	-	National Institution for Transforming India
NMSAR	-	National Maritime Search and Rescue
NOAA	-	National Oceanic and Atmospheric Administration
NOC	-	No Objection Certificate
NODC	-	National Oceanographic Data Centre
NODPAC	-	Naval Operations Data Processing and Analysis Centre
NPP	-	National Polar-orbiting Partnership
NRL	-	United States Naval Research Laboratory

NRSC	-	National Remote Sensing Centre
NTWC	-	National Tsunami Warning Centre
OBIS	-	Ocean Bio-Informatics System
ODG	-	Ocean Observations and Data Management Group
O-MASCOT	-	Ocean - Modelling, Data Assimilation and Process SpeCificObservaTions
OMM	-	Ocean Mixing and Monsoon
ONGC	-	Oil and Natural Gas Corporation Limited
ORV	-	Ocean Research Vessel
OSCAR	-	Ocean Surface Current Analyses Real-time
OTR	-	One Time Registration
PFZ	-	Integrated potential fishing zone
PI	-	Project Investigator
PIP	-	Points In Polygon
PMC	-	Project Management Committee
PMEL	-	Pacific Marine Environmental Laboratory
POGO	-	Partnership for Observation of the Global Oceans
POS	-	Polar Orbiting Satellites
QMF	-	Quality Management Framework
QuickSCAT	-	Quick Scatterometer
RAC	-	Research Advisory Committee
RADAR	-	RAdio Detection And Ranging
RAMA	-	Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
RC	-	Regional centre RCM
RCM	-	Rotor Current Meter
RE	-	Representation Errors
RGUKT	-	Rajiv Gandhi University of Knowledge Technologies
RIKEN	-	Rikagaku Kenky**hū**jyo- Designated National Research and Development Institute in Japan
RIMES	-	Regional Integrated Multi-Hazard Early Warning System
RISDA	-	RIKEN International School on Data Assimilation
ROMS	-	Regional Ocean Modeling system
RTI	-	Right to Information Act
SA	-	Situation Analysis
SAC	-	Space Applications Centre, Ahmedabad
SAP	-	Systems, Applications & Products in data processing
SARAT	-	Search and Rescue Aid Tool

SATCORE	-	SATellite Coastal and Oceanographic REsearch
SC	-	Steering Committee
SCI	-	Shipping Corporation of India
SCOR	-	Scientific Committee on Oceanic Research
SCR	-	Shoreline Change Rate
SEA-HOOFS	-	HOOFS for the South Eastern Arabian Sea
SeaWiFS	-	Sea-Viewing Wide Field-of-View Sensor
SG	-	Steering Group
SIBER	-	Sustained Indian Ocean Biogeochemistry and Ecosystem Research
SLA	-	Sea Level Anomaly
SLP	-	Sea Level Pressure
SMS	-	Short Messaging Service
SN	-	Sagar Nidhi
SNIT	-	Sreenidhi Institute of Science and Technology
SoI	-	Survey of India
SOP	-	Standard Operating Procedure
SS	-	Sagar Sampada
SSC	-	Science Steering Committee
SSH	-	Sea Surface Height
SSS	-	Sea Surface Salinity
SST	-	Sea Surface Temperature
STB	-	Surface Tsunami Buoy
SW	-	SouthWest
T/S	-	Temperature and Salinity
TB	-	Tera Bytes
TCS	-	Tata Consultancy Services
TEMPP	-	Tsunami Evacuation Maps, Plans and Procedures
TF	-	Tera Flop
TKE	-	Turbulent Kinetic Energy
TM	-	Thematic Mapper
TOLIC	-	Town Official Language Implementation Committee
TPG	-	Training and Programme Planning and Management Group
T-SIS	-	Tentral Statistical Interpolation
TSM	-	Total Suspended Matter
TSPs	-	Tsunami Service Providers
TWCs	-	Tsunami Warning Centres
TWG	-	Tsunami and Storm Surge Early Warning Services Group

UCDI	-	Union Commission on Data and Information
UGC	-	University Grants Commission
UK	-	United Kingdom
UNESCO	-	Intergovernmental Oceanographic Commission/ United Nations Educational, Scientific and Cultural Organization
USA	-	United States of America
USGS	-	United States Geological Survey
UTC	-	Coordinated Universal Time
VBIT	-	Vignana Bharathi Institute of Technology
VIIRS	-	Visible Infrared Imaging Radiometer Suite
VMP	-	Vertical Microstructure Profiler
VSAT	-	Very Small Aperture Terminal
WC-HOOFS	-	HOOFS for the west coast of India
WG	-	Working Group
WMO	-	World Meteorological Organization
WOD	-	World Ocean Data
WRF-ARW	-	Weather Research and Forecasting model - Advanced Research WRF core
XBT	-	Expendable Bathy Thermograph
XCTD	-	Expendable CTD

13. Finance

Appendix-1

Y Chakravarthy Associates
CHARTERED ACCOUNTANTS

Head Office:
#6-3-841/1/A,
Padma Plaza, II Floor, Ameerpet,
Hyderabad - 500 016
email: yca_fca@yahoo.com

AUDITORS' REPORT

To

The Chairman and Members,
Governing Council,
ESSO-INDIAN NATIONAL CENTRE FOR
OCEAN INFORMATION SERVICES,
Ocean Valley, Pragathinagar (BO), Nizampet (SO)
Hyderabad – 500 090

We have audited the attached Balance Sheet of the ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES as at 31st March 2018, and also the Income & Expenditure Account and Receipts & Payments Account for the year ending on that date annexed thereto. These financial statements are the responsibility of the Society's Management. Our responsibility is to express an opinion on the financial statements based on our Audit.

We conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material mis-statements. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion and report that:

1. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our Audit.
2. In our opinion, proper books of accounts as required by the Society, have been kept by the Society so far as appears from our examination of such books.
3. The Balance Sheet, Income & Expenditure Account, Receipts & Payments Account are in agreement with the Books of Account.
4. In our opinion and to the best of our information and according to the explanations given to us and subject to the notes forming part of accounts, the Balance Sheet as at 31st March 2018, Income & Expenditure Account and Receipts & Payments Account for the year ending on that date together with the Schedules and Notes on Accounts Annexed therewith give a true and fair view of the state of affairs of the Society.

For **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M.No. : 206456
FRN No.: 007907S

Place: Hyderabad
Date: 10.08.2018

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(Ministry of Earth Sciences, Govt. of India)
"Ocean Valley", Pragathinagar (BO), Nizampet (SO), Hyderabad - 500 090

BALANCE SHEET AS AT 31st MARCH 2018

Particulars	Schedules	Current Year (2017-18) ₹	Previous Year (2016-17) ₹
LIABILITIES			
Corpus fund	1	16,31,42,934	18,67,62,652
Earmarked funds	2	(2,22,49,991)	22,16,21,362
Current liabilities & Provisions	3	12,56,89,642	11,06,30,277
Total		**26,65,82,585**	**51,90,14,291**
ASSETS			
Fixed Assets	4	4,10,22,860	5,06,95,617
Current Assets, Loans & Advances	5	22,55,59,725	46,83,18,674
Total		**26,65,82,585**	**51,90,14,291**
Notes forming part of Accounts	11		

As per our report of even date
For **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M. No. 206456
FRN No: 007907S

For and on behalf of
ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)
Sr. Accounts Officer

(S.S.C. Shenoi)
Director

Place: Hyderabad
Date: 10.08.2018

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(Ministry of Earth Sciences, Govt. of India)
"Ocean Valley", Pragathinagar (BO), Nizampet (SO), Hyderabad - 500 090

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st MARCH 2018

Particulars	Schedules	Current Year (2017 - 18) ₹	Previous Year (2016 - 17) ₹
INCOME			
Income from Sales / Other Income	6	56,90,624	44,63,065
Interest Earned on Investments	7	64,05,211	46,77,951
Recurring Grants	8	23,17,30,000	35,00,00,000
TOTAL - A		**24,38,25,835**	**35,91,41,016**
EXPENDITURE			
Establishment Expenditure	9	12,14,30,908	12,88,03,070
Other Administrative Expenses	10	12,77,11,604	16,29,62,816
Depreciation	4	1,83,03,041	6,01,13,782
TOTAL - B		**26,74,45,553**	**35,18,79,668**
Excess of Income over expenditure (A-B)	1	**(2,36,19,718)**	**72,61,348**
Add / Less: Prior Period Items			
Balance being net income / deficit transferred to Corpus Fund		**(2,36,19,718)**	**72,61,348**
Notes forming part of Accounts	11		

As per our report of even date
For **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M. No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 10.08.2018

For and on behalf of
ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)
Sr. Accounts Officer

(S.S.C. Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(Ministry of Earth Sciences, Govt. of India)

"Ocean Valley", Pragathinagar (BO), Nizampet (SO), Hyderabad - 500 090

RECEIPTS AND PAYMENTS ACCOUNT FOR THE YEAR ENDED 31st MARCH 2018

RECEIPTS	CURRENT YEAR 2017-18		PAYMENTS	CURRENT YEAR 2017-18	
	₹	₹		₹	₹
Opening Balance			**Establishment Expenses**		
INCOIS Current A/c-SBI-HAL Campus Br.	4,91,80,820		Pay, Leave Salary Allowace	13,42,59,043	
INCOIS Current A/c-AB-Pragathi Nagar Br.	15,55,699		NPS, CPF, IDBPS	1,77,50,327	
INCOIS Consultancy SB A/c - Pragathi Nagar Br.	18,01,952		Staff Welfare	18,39,320	
Short Term Deposits with Bank	34,65,00,000	**39,90,38,471**	Leave Travel Concession Expenses	13,54,410	**15,52,03,100**
Additions					
INCOIS IGOOS Secretariat- Local	17,90,424		**Administrative Expenses**		
INCOIS IGOOS Secretariat- Foreign	18,42,405		Maintenance & Repairs	2,76,72,610	
Andhra Bank PORSEC 2012 Savings Bank Account	32,587		Travel Expenses - Inland	21,60,810	
INCOIS - CPF Account	1,70,510		Foreign	12,92,796	
INCOIS - IDBPS Account	99,737		Others	75,721	
INCOIS- ISPRS	2,89,725		Emoluments to Consultants	7,23,704	
AB PORSEC -Deposit	27,00,000	**69,25,387**	Subscription to Newspapers/Journals	42,561	
			Vehicle Hiring	7,39,494	
Earmarked Funds			House Keeping, Plumbing & Garden Expenses	1,41,31,619	
Construction of New Building (Phase II)	2,00,00,000		Security Expenses	1,68,87,939	
Ocean Information and Advisory Services(O-IAS)	18,00,00,000		Electricity Expenditure	2,77,53,166	
Ocean Observation Systems (OOS)	9,83,00,000		Water Expenses	45,87,917	
International Training Centre for Operational Oceanography (ITCOOcean)	4,00,00,000		Postage & Telegraphs	85,156	
Ocean Modeling, Data Assimilation and Process Specific Observation (O-MASCOT)	10,78,00,000		Telephone & Fax Expenditure	5,52,223	
Regional Integrated Multi-Hazard Early Warning System (RIMES)	7,00,00,000		Honorarium to External Experts	1,60,000	
Monsoon Mission	6,34,00,000		Conveyance Expenses	1,912	
Maintenance of ISGN Network (VSAT)	1,58,00,000	**59,53,00,000**	Printing & Stationery	14,74,318	
			Advertisement & Publicity	27,14,224	

BG Encashment (Phase II)	3,26,00,000	**3,26,00,000**	General Expenses	13,44,572	
			Audit Fee	18,717	
Recurring Grants	23,17,30,000	**23,17,30,000**	Seminar, Conference & Workshop Expenses	13,46,771	
			International Interface	6,52,811	
Other Receipts			Air & Electrical Expenses	1,18,14,893	
Consultancy Projects - Sundry Debtors	57,92,288		Material Consumable	4,68,951	
Earnest Money Deposits	1,01,61,053		Pest Control Expenses	1,38,138	
Security Deposits	50,860		Internet Expenses	8,67,727	
LTC Advance	21,568		Office Expenses	1,01,93,659	**12,79,02,409**
Interest on Short Term Deposits	1,58,85,987				
Interest on Bank Account	1,29,433				
Interest on Vehicle Advance	3,18,157		Payments Against Earmarked Funds		
Interest Margin Money TDR's	5,10,489		Construction of New Building (Phase II)		
Inspire /UGC Fellowship	10,72,962		Construction buildings	1,41,10,621	
EM Other Receipts-PHASE-II	21,93,229		Equipment	1,26,543	
EM Other Receipts-ITCOO	4,32,99,222		Administrative Expenses	58,340	
Income from MP Hall	59,455		Travel	37,270	**1,43,32,774**
Income from Tender Sales	17,900				
Interest on Income Tax Refund	9,63,401		**OASIS**		
Income from Guest House	2,89,561		Construction of seismic cabins in Andaman	92,15,135	
RTI Fee	280		Equipments	3,39,79,696	
Other Receipts	2,50,000		Hardware/Software	27,43,935	
Vehicle Advance to Employees	70,000		Technical Support	3,72,61,866	
DST Women in Science Fellowship	4,50,000		Administrative Expenses	1,33,51,571	
National Post Doctoral Fellow	9,60,000		Travel	39,42,879	
IT refund for FY 2013-2014	40,95,241		Consumable Material	48,286	
IT refund for FY 2012-2013	41,31,148	**9,07,22,234**	Advance against subprojects	2,25,75,569	
			Advance for Purchase	4,48,85,276	
Unspent Balances received from Sub Projects:			Margin Money against LC	75,31,000	
Ocean Advisory & Information Services, Computational Infrastructure and Communication System (OASIS)	9,62,764		Data	43,22,906	
Ocean Observation Network	39,94,710		Seminar Conference	25,60,893	
HROOF	17,03,759		Manpower	2,42,05,932	

SATCORE	89,107	**67,50,340**	Telephone Expenses	7,51,128	
			Depository Work	93,60,322	
Margin Money			Others	1,59,500	**21,68,95,894**
RIMES	23,33,000				
OASIS	2,75,31,000		Ocean Observation Networks - OON		
OON	8,46,00,000	**11,44,64,000**	Seminar Conference	7,33,720	
			Manpower	20,56,565	
Interest on Savings	2,36,754		Technical Support	75,58,991	
Amount Received from UNESCO	11,80,087		Administrative Expenses	39,95,365	
CPF Contribution	47,02,247	**61,19,088**	Travel	11,52,935	
			Consumable Material	7,74,750	
			Advance against subprojects	4,61,26,000	
			Advance for Purchase	7,43,70,831	
			Margin Money against LC	3,71,00,000	
			Data	48,29,605	
			Telephone Expenses	1,10,994	**17,88,09,756**
			Satellite Coastal and Oceanographic Research		
			Equipments	24,115	
			Administrative Expenses	23,153	
			Travel	1,23,966	
			Consumable Material	49,949	
			Advance against subprojects	2,37,135	
			Advance for Purchase	6,60,012	
			Seminar Conference	19,800	
			Manpower	13,35,942	
			Telephone	8,115	**24,82,186**
			International Training Centre (ITCOocean)		
			Equipments	4,39,298	
			Technical support	23,08,605	
			Administrative Expenses	13,38,858	
			Travel	11,83,106	
			Advance for Purchase	3,48,405	

			Deposit Works (APWD & RITES)	14,50,00,000	
			Telephone	4,987	
			Manpower	5,67,441	
			Seminar Conference	4,96,927	**15,16,87,626**
			O-MASCOT		
			Technical support	47,19,056	
			Adminisrtrative expenses	3,46,660	
			Travel	4,84,474	
			Advance against subprojects	66,00,000	
			Seminar Conference	1,31,690	
			Manpower	26,09,022	
			Telephone	6,642	**1,48,97,544**
			V Sat Terrestrial Link		
			Technical support	2,71,37,910	
			Adminisrtrative expenses	25,71,353	
			Travel	2,63,560	**2,99,72,823**
			Multi Hazard Vulnerability		
			Technical support	19,38,33,864	
			Adminisrtrative expenses	59,148	
			Travel	76,810	
			Data	11,60,00,000	
			Seminar	10,160	
			Telephone	11,907	**30,99,91,889**
			Monsoon Mission		
			Advance for Purchase	44,715	**44,715**
			RIMES Afro Asian Region		
			Equipments	20,58,886	
			Adminisrtrative expenses	15,000	
			Travel	30,144	

			Advance against subprojects	4,54,30,871	
			Advance for Purchase	1,57,81,099	
			Seminar	2,000	**6,33,18,000**
			IIOE2		
			Adminisrtrative expenses	8,27,748	
			Travel	2,38,990	
			Consumable Materials / Data	22,080	**10,88,818**
			NCS		
			Advance for Purchase	14,00,384	**14,00,384**
			Expenditure on Fixed Assets		
			Plant & Machinery	67,555	
			Furniture & fixtures	39,682	
			Office Equipment	55,427	
			Computer Peripherals	11,49,578	
			Electrical Installations	31,447	
			Library Books	63,77,918	
			Other Fixed Assets	16,400	
			Vehicles	8,92,277	**86,30,284**
			Other Payments		
			Earnest Money Deposits	67,34,990	
			Security Deposits	22,82,560	
			Bank Guarantee	4,13,165	
			Service Tax paid	3,18,158	
			Inspire Fellowship	15,000	
			Advance for purchase	6,13,520	
			LTC Advance	15,65,381	**1,19,42,774**
			Bank Charges	656	
			Unspent Balance transfer to Unesco	7,11,492	
			IGOOS Foreign Travel Expenses	11,41,469	

			CPF Withdrawals	5,71,400	**24,25,017**
			Closing Balance		
			INCOIS Current A/c-SBI-HAL Campus Br.	11,03,47,172	
			INCOIS Savings A/c-AB-Pragathi Nagar Br.	31,54,175	
			INCOIS Consultancy SB A/c - Pragathi Nagar Br.	3,82,809	
			Short Term Deposits with Bank	6,93,00,000	
			Andhra Bank PORSEC 2012 Savings Bank Account	33,668	
			INCOIS IGOOS Secretariat- Local	6,55,390	
			INCOIS IGOOS Secretariat- Foreign	12,49,333	
			INCOIS- CPF Account	43,97,251	
			INCOIS- IDBPS Account	1,03,333	
			INCOIS- ISPRS	3,00,397	
			AB PORSEC -Deposit	27,00,000	**19,26,23,527**
Total	**1,48,36,49,520**	**1,48,36,49,520**	**Total**	**1,48,36,49,520**	**1,48,36,49,520**

As per our report of even date
For **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M. No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 10.08.2018

For and on behalf of
ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)
Sr. Accounts Officer

(S.S.C. Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES
(Ministry of Earth Sciences, Govt. of India)
"Ocean Valley", Pragathinagar (BO), Nizampet (SO), Hyderabad - 500 090

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31st MARCH 2018

SCHEDULE 1 – CORPUS FUND

Particulars	Current Year (2017 - 18) ₹	Previous Year (2016 - 17) ₹
Corpus Fund at the beginning of the year	18,67,62,652	17,95,01,304
Add: Net income transferred from Income & Expenditure Account	(2,36,19,718)	72,61,348
BALANCE AS AT THE YEAR END	**16,31,42,934**	**18,67,62,652**

As per our report of even date
For **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M. No. 206456
FRN No: 007907S

Place: Hyderabad
Date: 10.08.2018

For and on behalf of
ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

(S. Nageswara Rao)
Sr. Accounts Officer

(S.S.C. Shenoi)
Director

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 2 - EARMARKED FUNDS

(Amount in Rs.)

Particulars	FUND-WISE BREAK UP														TOTALS	
	Building Fund	OASIS	Ocean Observation Networks	SATCORE	ITCOO	O-MASCOT	IT & E Governance Fund	V SAT Node	MH Vulnerability	Monsoon Mission	RIMES	CSS	IIOE2	NCS	Current Year 2017-18	Previous Year 2016-17
a) Opening balance of the funds	-1,06,76,474	-3,23,97,859	-3,86,77,413	55,97,198	3,15,06,594	1,69,23,468	28,99,468	2,94,08,541	13,86,01,916	6,66,65,188	65,43,465	5,53,058	27,85,416	18,88,795	22,16,21,362	3,98,75,963
b) Additions to the Funds:																
i. Grants	2,00,00,000	18,00,00,000	9,83,00,000	-	4,00,00,000	10,78,00,000	-	1,58,00,000	-	6,34,00,000	7,00,00,000	-	-	-	59,53,00,000	68,02,50,000
ii. Interest if any	61,642	3,13,329	5,68,058	1,95,357	47,01,996	32,36,006	1,33,404	10,96,401	46,19,042	40,48,137	8,58,245	25,513	1,01,723	76,552	2,00,35,405	1,91,43,627
iii. Advance for sub projects utilised/refund	-	2,90,47,560	5,62,57,345	52,12,733	-	2,30,04,906	-	-	-	-	7,06,96,048	-	-	-	18,42,18,592	17,58,28,462
iv. Advance for purchase Utilised	-	50,03,220	2,42,878	-	-	-	-	-	-	-	-	-	-	-	52,46,098	36,37,62,560
v. Margin Money Reversed	-	2,75,31,000	8,46,00,000	-	-	-	-	-	-	-	23,33,000	-	-	-	11,44,64,000	4,99,58,100
vi. Deposit Advance Utilized/refund	-	93,60,322	-	-	18,85,02,022	-	-	-	-	-	-	-	-	-	19,78,62,344	12,69,77,752
vii. Mobilization Advance Reversed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70,38,000
viii. Other Revenue	21,93,229	-	-	436	4,32,99,222	-	-	-	-	-	-	-	-	-	4,54,92,887	17,05,920
ix. BG encashment	3,26,00,000	-	-	-	-	-	-	-	-	-	-	-	-	-	3,26,00,000	-
TOTAL (a+b) - A	**4,41,78,397**	**21,88,57,572**	**20,12,90,868**	**1,10,05,724**	**30,80,09,834**	**15,09,64,380**	**30,32,872**	**4,63,04,942**	**14,32,20,958**	**13,41,13,325**	**15,04,30,758**	**5,78,571**	**28,87,139**	**19,65,347**	**1,41,68,40,688**	**1,46,45,40,384**
c) Utilisation/Expenditure																
i. Capital Expenditure																
W.I.P	1,41,10,621	92,15,135	-	-	23,48,38,906	-	-	-	-	-	-	-	-	-	25,81,64,662	15,00,95,710
Architect fee	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Equipments	1,26,543	3,44,10,541	1,77,47,404	24,115	56,856	38,43,506	-	-	-	-	20,58,886	-	-	-	5,82,67,851	35,00,50,793
Computers / Software	-	31,34,043	5,63,922	-	-	6,94,238	-	-	-	-	-	-	-	-	43,92,203	2,37,81,771
Other Assets	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**1,42,37,164**	**4,67,59,719**	**1,83,11,326**	**24,115**	**23,48,95,762**	**45,37,744**	**-**	**-**	**-**	**-**	**20,58,886**	**-**	**-**	**-**	**32,08,24,717**	**52,39,28,274**
ii. Revenue Expenditure																
Technical support	-	4,31,07,701	75,58,991	-	23,08,605	47,19,056	-	2,71,37,910	19,38,33,864	-	4,86,58,853	-	-	-	32,73,24,979	9,80,25,476
Adminisrtrative expenses	58,340	6,33,18,230	2,31,52,590	53,35,991	24,08,213	1,73,24,430	-	25,71,353	81,215	-	17,000	-	8,27,748	-	11,50,95,109	11,75,56,404
Travel	37,270	65,63,111	32,89,861	1,94,782	11,83,106	16,21,762	-	2,63,560	76,810	-	30,144	-	2,38,990	-	1,34,99,396	2,28,89,242
Consumable Materials / Data	-	89,84,893	1,53,58,689	4,43,385	-	11,15,462	-	-	11,60,00,000	-	-	-	22,080	-	14,19,24,508	7,42,27,151
Total	**95,610**	**12,19,73,935**	**4,93,60,131**	**59,74,158**	**58,99,923**	**2,47,80,710**	**-**	**2,99,72,823**	**30,99,91,889**	**-**	**4,87,05,997**	**-**	**10,88,818**	**-**	**59,78,43,993**	**31,26,98,273**
iii. Others																
Advance against subprojects	-	2,25,75,569	4,61,26,000	2,37,135	-	83,00,000	-	-	-	-	6,74,68,065	-	-	-	14,47,06,769	7,24,39,313
Advance for Purchase	-	7,21,12,754	7,43,70,831	6,60,012	3,48,405	-	-	-	-	44,715	1,57,81,099	-	-	14,00,384	16,47,18,200	17,40,60,814
Deposit Works (APWD & RITES)	-	-	-	-	14,50,00,000	-	-	-	-	-	-	-	-	-	14,50,00,000	7,43,98,048
Margin Money against LC	-	2,75,31,000	3,84,66,000	-	-	-	-	-	-	-	-	-	-	-	6,59,97,000	8,53,94,300
Total	**-**	**12,22,19,323**	**15,89,62,831**	**8,97,147**	**14,53,48,405**	**83,00,000**	**-**	**-**	**-**	**44,715**	**8,32,49,164**	**-**	**-**	**14,00,384**	**52,04,21,969**	**40,62,92,475**
TOTAL (i+ii+iii) - B	**1,43,32,774**	**29,09,52,977**	**22,66,34,288**	**68,95,419**	**38,61,44,090**	**3,76,18,454**	**-**	**2,99,72,823**	**30,99,91,889**	**44,715**	**13,40,14,047**	**-**	**10,88,818**	**14,00,384**	**1,43,90,90,679**	**1,24,29,19,022**
Amount Refunded-C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NET BALANCE AS AT THE PERIOD END {A-(B+C)}	**2,98,45,623**	**-7,20,95,405**	**-2,53,43,420**	**41,10,305**	**-7,81,34,256**	**11,33,45,926**	**30,32,872**	**1,63,32,119**	**-16,67,70,931**	**13,40,68,610**	**1,64,16,711**	**5,78,571**	**17,98,321**	**5,64,963**	**(2,22,49,991)**	**22,16,21,362**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 3 CURRENT LIABILITIES & PROVISIONS

Particulars	Current Year (2017 - 18) ₹	Previous Year (2016 - 17) ₹
A. CURRENT LIABILITIES		
Earnest Money Deposit	82,29,793	40,58,730
Security Deposit	93,71,163	69,39,834
Outstanding Expenses	1,20,54,239	1,91,03,953
Sundry Creditors	3,08,87,131	2,29,44,759
INSPIRE/DISHA/RTF-DCS Fellowship	(4,80,578)	3,30,339
Total – A	**6,00,61,747**	**5,33,77,615**
B. PROVISIONS		
Gratuity	2,88,15,430	2,52,17,407
Accumulated Leave Encashment	3,68,12,465	3,20,35,255
Total – B	**6,56,57,895**	**5,72,52,662**
Total (A+B)	**12,56,89,642**	**11,06,30,277**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE – 4 FIXED ASSETS **(Amount in Rs.)**

DESCRIPTION (% of Depreciation)	GROSS BLOCK			DEPRECIATION			NET BLOCK	
	As at 31.03.2017	Additions during the year	As at 31.03.2018	As at 31.03.2017	For the year 2017-18	As at 31.03.2018	As at 31.03.2018	As at 31.03.2017
1. Land (0%)	1,000	-	1,000	-	-	-	1,000	1,000
2. Plant, Machinery & Equipments (15%)	4,53,57,169	67,555	4,54,24,724	4,44,90,829	1,40,084	4,46,30,913	7,93,811	8,66,340
3. Furniture & Fixtures (10%)	1,72,27,402	39,682	1,72,67,084	1,11,36,165	6,13,092	1,17,49,257	55,17,827	60,91,237
4. Office Equipment (15%)	33,56,492	55,427	34,11,919	24,78,901	1,35,796	26,14,697	7,97,222	8,77,591
5. Computer / Peripherals (40%)	12,78,68,183	11,49,578	12,90,17,761	9,39,37,111	1,38,11,332	10,77,48,443	2,12,69,318	3,39,31,072
6. Electric Installations (10%)	20,66,959	31,447	20,98,406	12,01,264	89,714	12,90,978	8,07,428	8,65,695
7. Library Books (40%)	7,05,98,492	63,77,918	7,69,76,410	6,67,78,446	28,07,247	6,95,85,693	73,90,717	38,20,046
8. Other Fixed Assets (15%)	65,58,641	16,400	65,75,041	27,43,860	5,74,677	33,18,537	32,56,504	38,14,781
9. Vehicles (15%)	18,49,835	8,92,277	27,42,112	14,21,980	1,31,099	15,53,079	11,89,033	4,27,855
Total	**27,48,84,173**	**86,30,284**	**28,35,14,457**	**22,41,88,556**	**1,83,03,041**	**24,24,91,597**	**4,10,22,860**	**5,06,95,617**
Previous Year	25,92,02,101	1,56,82,072	27,48,84,173	16,40,74,774	6,01,13,782	22,41,88,556	5,06,95,617	9,51,27,327

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE - 5 CURRENT ASSETS, LOANS & ADVANCES

Particulars	Current Year (2017 - 18) ₹		Previous Year (2016-17) ₹	
A. CURRENT ASSETS				
1. Inventories (Valued at cost)	4,52,241	4,52,241	8,43,468	8,43,468
2. Cash & Bank Balance :				
a) With Scheduled Banks – Current Account				
State Bank of India HAL CAMPUS A/c	11,03,47,172		4,91,80,820	
Andhra Bank Pragathinagar SAVINGS A/c	31,54,175		15,55,699	
Andhra Bank Pragathinagar-Consultancy A/c	3,82,809	11,38,84,156	18,01,952	5,25,38,471
b) Short Term Deposits with SBI	6,93,00,000		34,65,00,000	
c) Short Term Deposits with AB		6,93,00,000	-	34,65,00,000
TOTAL A:		**18,36,36,398**		**39,98,81,939**
B. LOANS, ADVANCES & OTHER ASSETS				
1. Deposits				
a) Telephone	1,73,186		1,73,186	
b) Electricity	70,16,374		70,16,374	
c) Gas	13,100		13,100	
d) Petrol/Diesel	1,01,400	73,04,060	1,01,400	73,04,060
2. Advances & other amounts recoverable in cash or in kind or for value to be received				
a) Vehicle Advance to Employees	1,04,042		3,49,577	
b) Interest Accrued	1,27,20,142		1,22,31,769	
c) Other Advances	-		-	
d) Advance for Purchase	21,44,317		21,44,317	
e) Sundry Debtors	-		23,31,464	
f) Tour Advance	16,36,174		9,26,157	
g) LTC Advance	5,58,727		75,000	
h) TDS				
Opening Balance - Rs. 2,00,74,391				
Less: Refund received during the year Rs. (82,26,389)				
Add: Current year accumulation Rs. 21,94,699	1,40,42,701		2,00,74,391	
i) Margin Money against Bank Guarantee	34,13,165	3,46,19,238	2,30,00,000	6,11,32,675
TOTAL B: (1+2)		**4,19,23,328**		**6,84,32,675**
GRAND TOTAL (A + B)		**22,55,59,725**		**46,83,18,674**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 6 - INCOME FROM SALES / OTHER INCOME

Particulars	Current Year (2017-18) ₹	Previous Year (2016-17) ₹
a) Sale of Tender Forms	17,900	20,877
b) Other Receipts	19,54,678	6,29,168
c) Consultancy Services	31,60,860	31,47,433
d) Income from staff quarters	5,57,186	6,65,587
TOTAL	**56,90,624**	**44,63,065**

SCHEDULE 7 - INTEREST EARNED		
a) Interest on Short Term Deposits & Others	62,51,352	44,84,628
b) Bank Accounts	1,29,433	1,32,522
c) Staff Advances	24,426	60,801
TOTAL	**64,05,211**	**46,77,951**

SCHEDULE 8 - IRRECOVERABLE GRANTS & SUBSIDIES RECEIVED		
a) Central Government (Recurring Grant received from MoES)	23,17,30,000	35,00,00,000
TOTAL	**23,17,30,000**	**35,00,00,000**

SCHEDULE 9 - ESTABLISHMENT EXPENDITURE		
a) Salaries, Wages & Allowances	10,89,28,438	11,85,79,235
b) Staff Welfare Expenses	18,39,320	23,83,556
c) Contributory Provident Fund	8,83,882	2,75,229
d) New Pension Scheme	60,91,157	38,03,773
e) IDBPS Trust	23,33,615	13,29,371
f) Leave Travel Concession	13,54,496	24,31,906
TOTAL	**12,14,30,908**	**12,88,03,070**

ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES

SCHEDULE 10 - OTHER ADMINISTRATIVE EXPENSES

Sl No.	Particulars	Current Year (2017 - 18) ₹	Previous Year (2016 - 17) ₹
1.	Electricity & Power Expenses	2,96,86,666	3,55,66,921
2.	Water Charges	45,42,676	51,57,399
3.	Operation & Maintenance expenses	3,60,61,813	5,82,32,215
4.	Garden Expenses	12,53,395	-
5.	Vehicle Hiring Expenses	7,56,872	6,88,254
6.	Postage, Telephone, Fax & ISDN Charges	6,17,314	7,57,873
7.	Printing & Stationery	14,75,278	1,24,882
8.	Travelling Expenses :		
	Inland	22,72,166	30,97,141
	Foreign	17,25,531	9,78,875
	Others	75,721	2,65,098
9.	Seminar/Workshops Expenses	12,67,211	19,70,480
10.	General Expenses	1,11,40,960	88,93,200
11.	Audit Fee	16,666	30,921
12.	House Keeping & Plumbing	1,35,92,320	1,08,18,905
13.	Security Expenses	1,74,66,721	1,23,38,454
14.	Advertisement & Publicity	27,82,481	13,04,619
15.	Emoluments to Consultants	7,23,704	23,000
16.	Internet Expenses	8,67,727	-
17.	Legal Expenses	56,147	1,21,084
18.	Papers & Periodicals	42,561	34,388
19.	Conveyance Expenses	1912	1,45,353
20.	Material /Consumable	4,68,951	45,43,854
21.	International Interface	6,52,811	1,74,34,067
22.	Others	1,64,000	4,35,833
	TOTAL	**12,77,11,604**	**16,29,62,816**

SCHEDULE NO.11

NOTES FORMING PART OF ACCOUNTS:

1. **Significant Accounting Policies:**

a) **Basis of Accounting:**

The Society follows the mercantile system of Accounting and recognizes Income and Expenditure on accrual basis. The accounts were prepared on the basis as a going concern.

b) **Income Recognition:**

The Grant-in-aid was received by the Society from Ministry of Earth Sciences in the form of recurring grant and ear-marked funds.

The Grant-in-aid received from Ministry of Earth Sciences for the purpose of meeting revenue expenditure is treated as Income to the Society and to the extent utilized for capital expenditure is added to the Corpus Fund. During the year 2017-18, the Society received Rs.23.17 Crores towards Recurring Grant as shown in the Schedule-8.

The remaining Grant-in-aid of Rs. 59.53 Crores received from Ministry of Earth Sciences is being utilized for specific purposes for which they were intended and are disclosed under the Earmarked Funds- Schedule-2.

Encashment of Bank Guarantees of M/s Unity

In the Schedule-2, under building fund, an amount of Rs.3,26,00,000/- (Rupees three crores twenty six lakhs only) shown as receipt of funds. This is the amount received against the invoking the Bank Guarantee submitted by M/s Unity Infraprojects Limited in view of the non-renewal of the bank guarantees. Hence this amount is not recognized as income of the organization and kept separately.

c) **Fixed Assets and Depreciation:**

- Fixed Assets register was maintained by the Society.
- The management verified the assets physically by appointing a sub-committee.
- The additions to the fixed assets during the period of audit were stated at cost.
- Depreciation on Fixed Assets was provided on written down value, as per the rates prescribed under the Income Tax Rules.
- In view of the changes in the Income Tax Act, the depreciation rates applied in the current year 2017-18 are Computer/Peripherals 40% and Library Books @ 40%. In the year 2016-17 On Computer Peripherals, the depreciation was charged at 60% and on Library books charged at 100%.

d) **Inventories:**

Inventory of stores, stationery items and other material of significant value are valued at cost.

e) **Building:**

As per the guidelines provided to the Central Autonomous Bodies, the Funds inflow and outflow relating to the building are initially to be shown under Building Fund in the Earmarked Funds under Schedule – 2 and on completion of the building; the value of building is to be transferred to the Fixed Assets schedule.

f) **Employee Benefits:**

i) **Gratuity:**

The present value of the INCOIS obligations under Gratuity is recognized on the basis of an actuarial valuation made by LIC of India Ltd., as at the year end.

ii) **Pension:**

The IDBPS (INCOIS Defined Benefit Pension Scheme) is managed by a separate trust and employers contributions for the year 2017-18 towards pension for the employees joined prior to 01-01-2004, was transferred by INCOIS to LIC of India Ltd.

Based on the MoES letters, INCOIS requested all the 11 employees, who are under INCOIS-IDBPS, to exercise the option either to continue in the Contributory Provident Fund or to join the New Pension Scheme as the IDBPS is being discontinued in INCOIS. The funds transfer to LIC of India Limited towards contribution of INCOIS for the IDBPS is deferred with effect from September, 2015 onwards

As per the directives of the GC, INCOIS has sent a letter dated March 19, 2015 to Joint Secretary (Establishment), MoES requesting for post-facto approval for the Defined Benefit Pension Scheme (DBPS) which has been implemented since May 2010 for its employees joined service prior to 1.1.2004.

MoES vide its reply letter dated August 13, 2015 informed that the issue has been examined in consultation with IFD, MoES and it has not been found possible to accede to consider INCOIS proposal for ex-post-facto approval for the Defined Benefit Pension Scheme (DBPS) which has been implemented since May 2010 for its employees joined service prior to 1.1.2004.

The letter further informs that the demand for pension in respect of INCOIS employees who joined prior to 1.1.2004 may please be regulated in terms of guidelines issued vide letter No.MoES/01/Dir(F)/2015 dated May 26, 2015.

All 11 employees in the scheme contested the exercising the option given by the INCOIS and filed a legal case with Central Administrative Tribunal, Hyderabad on November 12, 2015. The hearings are going on. The court has issued status-quo orders on February 24, 2016.

Periodical contributions to IDBPS are charged to revenue up to August 31, 2015 only.

iii) Periodical contributions made towards Contributory Provident Fund (CPF), New Pension Scheme (NPS) are charged to revenue

iv) **Leave encashment:**

The present value of the INCOIS obligations under Leave encashment is recognized on the basis of an actuarial valuation made by LIC of India Ltd., as at the year end.

g) **Interest on Deposits:**

The Society invested surplus funds from time to time in Short Term Deposits in Nationalized Banks. For the year 2017-18, an amount of Rs.1,72,76,588/- was earned as interest on the Short Term Deposits in the bank. Since, the interest received on Short Term Deposits, relate to the grants accruing to the various projects and recurring grants received by INCOIS, the management decided to spread the interest on Short Term Deposits to such projects and INCOIS Society.

Accordingly, out of total interest of Rs.1,72,76,588/-, the management had transferred an interest of Rs.1,47,14,751/- to various projects classified in Earmarked Funds under Schedule – 2 and the balance interest of Rs.25,61,837/- was considered as income of the Society.

The details are furnished below:-

(Amount in Rs.)

a.	Interest earned on regular STDRs	1,42,52,565.00
b.	Add: TDS deducted by bank on interest earned	18,47,374.00
c.	Add: TDS deducted by bank & TSSPDCL on interest accrued	42,244.00
d.	Add: Accrued Interest as on 31.03.2018	11,90,090.00
e.	Total Interest	1,73,32,273.00
f.	Less: Accrued Interest as on 31.03.2017	55,685.00
g.	**Net Interest earned for the F Y 2017 - 18**	**1,72,76,588.00**

2. Notes on Accounts:

a) EARMARKED FUNDS:

The Society during the year 2017-18, received Rs. 59.53 Crores as Grant-in-aid towards Earmarked Funds from the Ministry of Earth Sciences (MoES) and other institutions in the form of Recurring and Non-Recurring grants as specified under Schedule -2.

The overall funds positions in the Ear-marked funds are negative. The funds were temporarily used by Management from other projects and will be replenished upon receipt of funds from the Ministry to avoid delay in execution of the projects.

In this regard, the 15th ESSO council meeting held on 30th September 2014 under point no.12 of page-3 of the minutes delegated the powers to the centre Directors and the same is re-produced below for your reference:-

"In order to carry out the activities without any hindrance and achieve the objectives as highlighted in the administrative order, the available funds may be utilized from the different heads with the approval of Institute Director subject to the condition that the overall estimated cost of the programme indicated in the Administrative Order should not exceed due to shortage of funds under the relevant programme (Action: Directors/Heads of Organization)". Accordingly, upon such approval, the Management utilized the available funds to meet the expenditure of the projects.

The amounts advanced to various Earmarked Funds under Schedule-2, shall initially be shown as Advances to Sub Projects' under "Others" category in the Earmarked Funds Schedule, and, on receipt of Utilisation Certificates from the respective project heads, the utilized amounts are transferred to either Capital expenditure or Revenue expenditure based on the nature of utilization.

INCOIS is making payments for the acquisition of equipment for the various projects classified under Earmarked Funds of Schedule-2. These payments are initially shown as 'advance for purchase' under Schedule-2, and later, on completion commissioning of the equipment, the total value of equipment is transferred to equipments under the same Schedule. The total value of "Advance for Purchase" as on 31-03-2018 was Rs. 66.93 Crores.

The accumulated value of the capital expenditure as on 31-03-2018 (excluding advances to sub- projects and advances for purchases), incurred in each year and specified in the Earmarked Funds under Schedule - 2, are stated below:

Sl No.	Name of the Fund/ Project	As on 01-04-2017 ₹	Additions 2017-18 ₹	Total Amount as on 31-03-2018 ₹
i)	Building Fund	57,54,46,710	1,42,37,164	58,96,83,874
ii)	MDC & Equipment Fund	6,59,21,618	0	6,59,21,618
iii)	Ocean Information and Advisory Services (OASIS)	1,54,22,12,332	4,67,59,719	1,58,89,72,051
iv)	Computational Facilities	15,28,06,467	0	15,28,06,467
v)	INDOMOD & SATCORE Projects	42,72,40,730	24,116	42,72,64,846
vi)	Ocean Observation Networks	57,94,24,888	1,83,11,326	59,77,36,214
vii)	International Training Center-ITCOocean	16,13,23,618	23,48,95,762	39,62,19,380
viii)	O-MASCOT (HROOFS)	1,54,04,580	45,37,744	1,99,42,324
ix)	HPC System - INCOIS	13,64,14,440	0	13,64,14,440
x)	IT & E Governance Fund	5,76,21,080	0	5,76,21,080
xi)	HPC Systems - Others	1,33,61,57,396	0	1,33,61,57,396
xii)	CSS	14,21,621	0	14,21,621
xiii)	V SAT Node	13,31,28,616	0	13,31,28,616
xiv)	Ernet India	72,00,000	0	72,00,000
xv)	IOAS	51,25,986	0	51,25,986
xvi)	MH Vulnerability	28,30,738	0	28,30,738
xvii)	Monsoon Mission	3,63,58,018	0	3,63,58,018
xviii)	RIMES	0	20,58,886	20,58,886
	Total	**5,23,60,38,838**	**32,08,24,717**	**5,55,68,63,555**

b) PROJECTS AND UTILISATION CERTIFICATES:

The Committees comprising the heads of respective projects and other technical/scientific experts are monitoring the status of the various projects, including the financial budgets etc. The recommendations of the committee are being reviewed from time to time by the competent authority.

The various assets of the projects and sub projects purchased either by the INCOIS or by the respective sub projects, are located at such projects and sub projects. The confirmations of the assets held by them are being submitted from time to time.

The respective project heads submitted the utilization certificates for the year ending 31st March of each financial year and these certificates are received by the INCOIS during the subsequent financial year. Hence, the management had decided to pass the entries relating to the Utilisation Certificates actually received upto 31st March of each financial year.

c) Contingent Liabilities:

i. Contingent liabilities not provided for : There is a legal dispute going on with M/s Unity Infraprojects Limited and the firm's Bank Guarantee was encashed amounting to Rs.3,26,00,000/-. Depending upon the judgment of the case, the action will be taken in future.

ii. Estimated amount of Contracts remaining to be executed on capital account-NIL

iii. Claims against the company not acknowledged as debts-NIL

d) I The society had placed an order with M/s. Victory Genset Pvt. Ltd for purchase of two 600 KVS DG sets in the year 2009 and released 90% payment by irrecoverable LC as per terms agreed. But, M/s. Victory Genset Pvt. Ltd had supplied only one DG set. The society claims that the documents were fabricated by supplier as if two DG sets have been supplied and hence, filed a criminal and civil suit in 2009 against the supplier.

II The III Additional Chief Judge of City Civil Court, Hyderabad, had passed a decree for Rs.64,89,747/- plus damages Rs.5,00,000/- with future interest till the date of payment by the firm vide their Order OS No.69 of 2010, dated 18-04-2012. During the proceedings of the case, an amount of Rs.18,50,907.98 was blocked through injection petition in the current account of M/s. Victory Genset Pvt. Ltd. maintained at SBI, Versova Branch, Mumbai.

III Upon grant of decree by Hon'ble court, the society on the advice of legal advisor had requested SBI Versova Branch, Mumbai to transfer the available amount to INCOIS and to provide the details of assets of M/s Victory Genset Pvt. Ltd. to file the petition to recover the balance amount. As SBI, Versova Branch refused to honour the court decree; the society had written letters to Governor, Reserve Bank of India & Secretary, Ministry of Finance, Govt. of India complaining against the SBI, Versova Branch for not adhering to the court decree. No response is received from the above.

IV Society now filed an Executive Petition at III Additional Chief Judge of City Civil Court, Hyderabad for recovery of the amount available in the bank account of M/s Victory Genset Pvt.Ltd.at SBI, Versova Branch, Mumbai. The case is in progress.

e) **Input Tax Credit of GST**
INCOIS is being a Scientific Organization mandated with providing ocean data, information and advisory services to the society, industry, the Government and Scientific Community. There is an imbalance of payment of GST against the Purchases made and services obtained against input tax credit claimed. The matter is discussed with GST Department. Since Input GST is not agreed by the GST Department as credit allowable, GST is treated as part of expenditure and GST collected as output GST, is treated as Income in the books of Accounts whereas while filing GST return we claim ITC and set off against Output GST.

f) **Bank Accounts not forming part of books, but shown in the Receipts and Payments.**
The main bank accounts that are operated for the society are shown in the books of accounts. Whereas the accounts that are operated for specific purpose are only shown this year in Receipts and Payments Account only by the Management as per the suggestion made by Scientific Audit Department of C&AG.

g) Figures of the previous year were regrouped wherever necessary.

h) Paise had been rounded off to the nearest rupee.

As per our report of even date
For **Y Chakravarthy Associates**
Chartered Accountants

Y Chakravarthy
Partner
M. No. 206456
FRN No: 007907S

For and on behalf of **ESSO-INDIAN NATIONAL CENTRE FOR OCEAN INFORMATION SERVICES**

(S. Nageswara Rao)
Sr. Accounts Officer

(S.S.C. Shenoi)
Director

Place: Hyderabad
Date: 10.08.2018

ESSO-Indian National Centre for Ocean Information Services

(An autonomous body under the Ministry of Earth Sciences, Govt. of India)

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