



ANNUAL REPORT 2010 - 2011



Indian National Centre for Ocean Information Services

(An Autonomous Body under the Ministry of Earth Sciences, Government of India)
'Ocean Valley', Hyderabad - 500 090

Contents

1.	Director's Report	03
2.	Our Organization	05
3.	Highlights	09
4.	Services	10
4.1	Potential Fishing Zone (PFZ) Advisories	10
4.2	Tuna Fishery Advisories	10
4.3	Ocean State Forecast	11
4.4	Coral Bleaching Alert System (CBAS)	13
4.5	Early Warning System for Tsunami and Storm Surges	14
4.6	Dissemination and User Interactions	15
5.	Observation Networks	17
5.1	Indian Argo Project	17
5.2	Other Ocean Observing Systems	17
6.	Research and Modelling	21
6.1	GODAS Assimilation System	21
6.2	Development of 0.25° x 0.25° Regional Indian Ocean Model using MOM4p1	22
6.3	CUPOM	22
6.4	Hycom	23
6.5	Research Findings During 2010-2011	24
7.	Satellite Coastal and Oceanographic Research	27
8.	Indian Ocean Modelling and Dynamics (INDOMOD)	31
9.	Ocean Data Management and Dissemination	31
10.	Web Services	32
11.	Infrastructure	32
11.1	Major Communication Installations at INCOIS During 2010-2011	32

12.	General Information	33
12.1	International Collaboration	33
12.2	Meetings/Workshops Organized by INCOIS	33
12.3	Distinguished Visitors	35
12.4	Symposia and lectures	36
12.5	Awards	36
12.6	Promotion of Hindi	38
12.7	Vigilance Activities	38
12.8	Reservation Policy	38
12.9	Right to Information Act	39
12.10	Results Frame Work Document	39
12.11	Deputations Abroad	39
12.12	Publications	42
12.13	Consultancy Projects	45
13.	List of Acronyms	46
14.	Finance	49
	Auditors' Report	50
	Balance Sheet	51
	Income and Expenditure Account for the Year ended 31 st March 2011	52
	Receipts and Payments Account for the Year ended 31 st March 2011	53
	Schedules Forming Part of Balance Sheet as at 31 st March 2011	57

1. Director's Report



I have great pleasure to present our centre's Annual Report for the year 2010-11. In 2010-11 also INCOIS could fulfill and strengthen its commitments as the national operational oceanographic centre. Our continued efforts to serve the society through ocean information services have proved to be contributing to the GDP of our country (Report prepared by National Council of Applied Economic Research, December, 2010).

Few new services have also been developed and made operational during this year in addition to the continuing services on the advisories and forecasts on potential fishing zones, waves and other ocean parameters for the benefit of fishermen, navigators, ports, harbors, and offshore industries. The 'High Wave Alert' that warns the coastal community about the impending high waves proved to be extremely useful in planning the disaster management activities during the passage of storms and cyclones. Another service, the 'Tide Predictions' provides 5 day predicted tides at 178 major and minor ports situated in India and neighboring countries. Operationalization of 'Tuna fishery advisory' based on satellite derived SST, Chlorophyll, water clarity (Kd490) and the mixed layer depth and setting up of a system to issue weekly bulletins on the 'health of coral reefs' along the Indian coast are the other two new services made operational during the past year. With the implementation of Global Ocean Data Assimilation System (GODAS) adopted from NOAA /NCEP, we have achieved the capability to generate the ocean analysis data on a regular basis. This model now assimilates data from Indian moored buoys and XBTs. The improvement in HYCOM is another notable achievement.

Our tsunami warning system worked as expected in detecting the earthquakes as well as in issuing timely warnings. The system detected 9 major earth-quakes ($M > 6.5$) in the Indian Ocean and 63 in the other oceans and issued bulletins and advisories as required to appropriate government agencies and authorities. Notable, among them was the 11 March 2011 event in Japan; the centre could issue the first bulletin, informing 'No Threat for the Indian Ocean region', within 7 minutes of the occurrence of earthquake off the east coast of Japan.

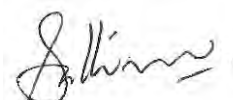
While providing the services to the society, INCOIS scientists also published 27 papers (total IF 33.9) in peer reviewed national and international journals.

On the international scenario, INCOIS continued the lead role in Indian Ocean Global Ocean Observing System (IOGOOS), Regional Co-ordination of Argo Programme and Partnership for Observation of Global Ocean (POGO) and collaboration with Regional Integrated Multi-hazard Early warning System (RIMES). The 7th annual meeting of IOGOOS, held in Perth, Australia in July 2010, extended the tenure of IOGOOS secretariat at INCOIS till 2013. During the year, INCOIS also agreed to host the international programme office for Sustained Indian Ocean Biogeochemistry and Ecosystem Research (SIBER).

INCOIS continued the support to the research projects executed by the Principal Investigators at national institutes and universities. While some of them contributed to the generation of data, the others contributed through publishing research papers in peer reviewed journals.

On the infrastructure front, we have initiated the construction activities to construct an additional floor on top of INCOIS main building and amenity building and the construction of guest house, residential complex, compound wall, etc.

I am thankful to my colleagues at INCOIS for their constructive suggestions, commitment, co-operation and devotion to work. All those achievements reported above are nothing but theirs. Finally, I take this opportunity to thank Dr. Shailesh Nayak, Chairman, Governing Council and members of GC for their support and guidance at every moment. I would also like to thank Chairman and members of Finance Committee and Research Advisory Council. I am also thankful to the colleagues at Ministry of Earth Sciences for their strong support and guidance in administration and implementation of projects. Sudheer Joseph, Satya Prakash, Venkat Seshu and Prince Prakash compiled the report using the inputs from other colleagues. I am extremely grateful to them as well as to my colleagues at INCOIS.



S.S.C. Sheno

2. Our Organization

The Indian National Centre for Ocean Information Services (INCOIS) is an autonomous body under the Ministry of Earth Sciences (MoES), Government of India, registered as a Society under the Andhra Pradesh (Telangana Area) Public Societies Registration Act 1350, Fasli at Hyderabad on February 3, 1999. The affairs of the Society are managed, administered, directed and controlled, subject to the Bye laws of the Society, by the Governing Council.

INCOIS Society

1. Secretary, Ministry of Earth Sciences	President
2. Director, National Remote Sensing Centre	Vice-President
3. Additional/Joint Secretary, Ministry of Earth Sciences	Member
4. Advisor, Ministry of Earth Sciences	Member
5. Director, National Institute of Oceanography	Member
6. Director, National Institute of Ocean Technology	Member
7. Director, National Centre for Antarctic & Ocean Research	Member
8. Director, Indian National Centre for Ocean Information Services	General Secretary

INCOIS Governing Council

1. Secretary, Ministry of Earth Sciences	Chairman
2. Dr. Harsh Gupta, Dr. N.K. Panikkar Chair, National Geophysical Research Institute	Vice-Chairman
3. Director, National Remote Sensing Centre	Member
4. Director General, India Meteorological Department	Member
5. Financial Adviser, Ministry of Earth Sciences	Member
6. Chairman, Research Advisory Council, INCOIS	Member
7. Additional/Joint Secretary, Ministry of Earth Sciences	Member
8. Director, National Centre for Antarctica and Ocean Research	Member
9. Director, National Institute of Oceanography	Member
10. Director, National Institute of Ocean Technology	Member
11. Principal Advisor (S&T), Planning Commission	Member
12. Director, Space Application Centre	Member
13. Director, Indian National Centre for Ocean Information Services	Member Secretary
14. Programme Officer, Ministry of Earth Sciences	Permanent Invitee

INCOIS Research Advisory Committee

- | | |
|--|------------------|
| 1. Dr. B.N. Goswami, Director,
Indian Institute of Tropical Meteorology | Chairman |
| 2. Dr. (Mrs). P. Venkatachalam, Principal Research Scientist,
Indian Institute of Technology, Mumbai | Member |
| 3. Dr. V. K. Dadhwal, Director, National Remote Sensing Centre,
Hyderabad | Member |
| 4. Dr. M. Dileep Kumar, Scientist -G, National Institute
of Oceanography, Goa | Member |
| 5. Dr. B. K. Saha, Adjunct Professor,
School of Oceanographic Studies, Jadavpur University, Kolkata | Member |
| 6. Dr. M. Ravichandran, Scientist-F, Indian National Centre
for Ocean Information Services, Hyderabad | Member secretary |

INCOIS Finance Committee

- | | |
|--|------------------|
| 1. Financial Adviser, MoES | Chairman |
| 2. Additional/Joint Secretary, MoES | Member |
| 3. Director, INCOIS | Member |
| 4. Director/Deputy Secretary (Finance), MoES | Member |
| 5. Programme Officer, MoES | Member |
| 6. Sri. Pattabhi Ramarao, Scientist, INCOIS | Member-Secretary |

The Mission

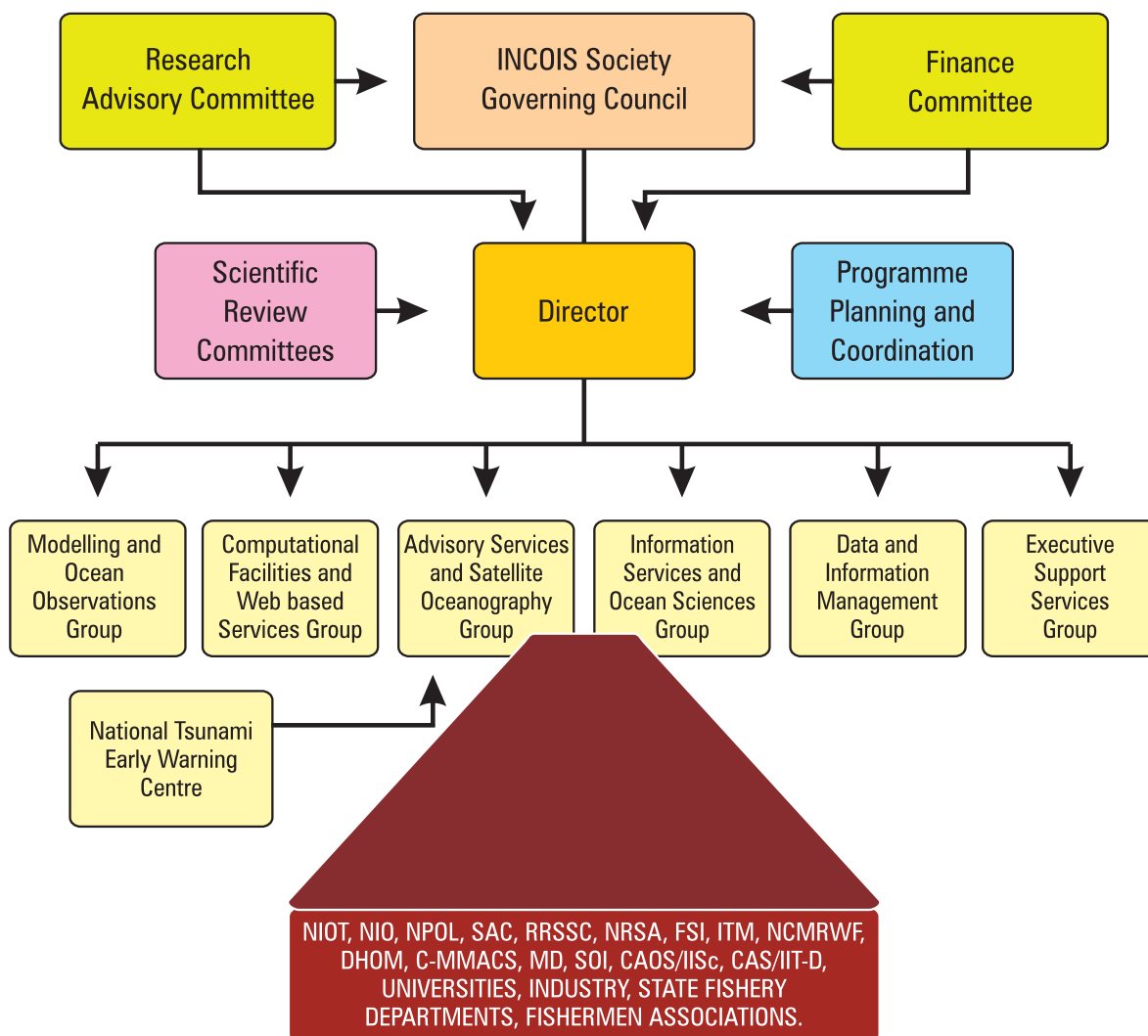
To provide ocean data, information and advisory services to society, industry, government and scientific community through sustained ocean observations, and constant improvements through systematic and focused research in information management and ocean modelling.

The major objectives of INCOIS are:

1. To establish, maintain and manage the systems for data acquisition, analysis, interpretation and archival for Ocean Information and Services.
2. To undertake, aid, promote, guide and co-ordinate research in the field of ocean information and 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 provide Early Warnings on Tsunami and Storm Surges.
7. To support the research centres to conduct investigations in specified areas related to oceanic processes, ocean atmospheric interaction, coastal zone information, data synthesis, data analysis and data collection.
8. To organize training, seminars and symposia to advance the 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 the societal needs in improving their living standards.
10. To provide consultancy services in the fields of ocean information and services.
11. To co-ordinate with the 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 INCOIS.

INCOIS, in its pursuit for organizational excellence, national relevance and international significance, translates the scientific knowledge into useful products and services through synergy and knowledge networking with centres of excellence in ocean sciences, atmospheric sciences, space applications, and information and communication technology.

INCOIS Organogram Structure is as given below:



INCOIS Organogram

3. Highlights

The Indian National Centre for Ocean Information Services (INCOIS), an autonomous body under the Ministry of Earth Sciences (MoES), evolving since February 1999, completed the 12th successful year in delivering ocean information and services to the country. The year 2010-11 also proved to be a productive year and witnessed many of its continued services including the quick response (within 7 minutes of the occurrence of earthquake) to the gigantic-tsunami event that occurred following the 9.0 M earthquake off the east coast of Japan on 11 March 2011.

Two new services, namely, 'High Wave Alert', 'Tide Predictions' were introduced for the Indian coastline to provide alerts on the high waves that might exist at specific locations along the coast line and to provide a 5 day prediction on the tides at 178 major and minor ports. The 'High Wave Alerts' have been found to be extremely useful by the disaster management authorities during the passage of atmospheric depressions and cyclones. Other achievements include the set up of high resolution operational wave forecast models for Andaman and Nicobar and Lakshadweep Islands.

Operational 'Tuna fishery advisory' based on satellite derived SST, Chlorophyll, water clarity (Kd490) and the mixed layer depth derived from models and setting up of a system to issue weekly bulletins on the 'health of coral reefs' along the Indian coast are other two achievements during the past year.

Implementation of Global Ocean Data Assimilation System (GODAS) adopted from NOAA/NCEP and the implementation of HYCOM on HPC at INCOIS were other significant developments during the past year. GODAS is being used for the generation of ocean analysis data and HYCOM is being used to simulate the inter-annual variability in the sea level and surface currents.

The achievements of tsunami warning service include the development and set up a Decision Support System that can guide the operator on issuing tsunami warnings.

On the research front, a total of 27 publications for the current financial year (2010-2011) has been produced from INCOIS with a total impact factor of 33.9. An important research finding during this year was that, the observed intra-seasonal variability of Barrier Layer Thickness (BLT) is mainly controlled by the vertical movement of Isothermal Layer (IL) in the presence of a shallow mixed layer. Further, the analysis showed that both Isothermal Layer Depth (ILD) and BLT are modulated by vertical stretching of the upper water column associated with westward propagating intra-seasonal Rossby waves in the southern bay. These waves are remotely forced by intra-seasonal surface winds in the equatorial Indian Ocean.

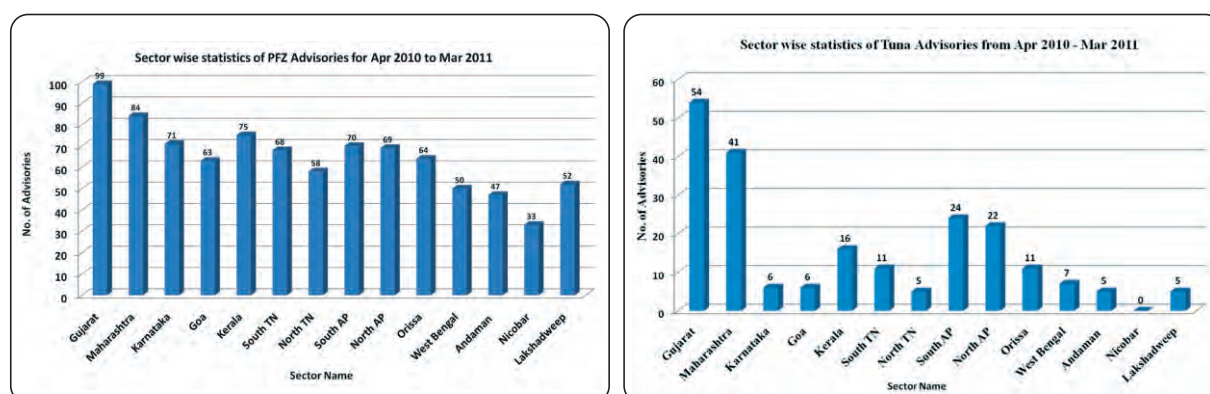
4. Services

4.1 Potential Fishing Zone (PFZ) Advisories

Like in the past years, INCOIS continued the generation and dissemination of the multi-lingual PFZ advisories based on Sea Surface Temperature (SST), chlorophyll and wind to the fishing community of India. PFZ advisories targeting 14 sectors namely, Gujarat, Maharashtra, Karnataka, Goa, Kerala, South Tamil Nadu, North Tamil Nadu, South Andhra Pradesh, North Andhra Pradesh, Orissa, West Bengal, Andaman Islands, Nicobar Islands and Lakshadweep Islands.

Cloud contamination is a persistent hurdle in the generation of PFZ advisories. The problem has now been resolved to some extent through the use of optimally interpolated (at 5 km spatial resolution) merged product of Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) from Global High Resolution Sea Surface Temperature (GHRSSST) Project. This was made operational in February, 2011. Due to the usage of OSTIA product and also due to the issuance of advisories on public holidays, the number of advisories issued during the last year increased by $\approx 36\%$.

The validation experiments carried out in Goa showed that the net profit increased to 1.5 to 2.5 times due to the increased catch and the reduced search time. The savings in fuel cost due to the reduction in search time was about 30%. Even during the lean months (for example, the month of June), usage of PFZ assured profit, though minimal, compared to the possible losses due to the fishing in non PFZ areas.



Number of PFZ and Tuna fishing advisories generated for different sectors.

4.2 Tuna Fishery Advisories

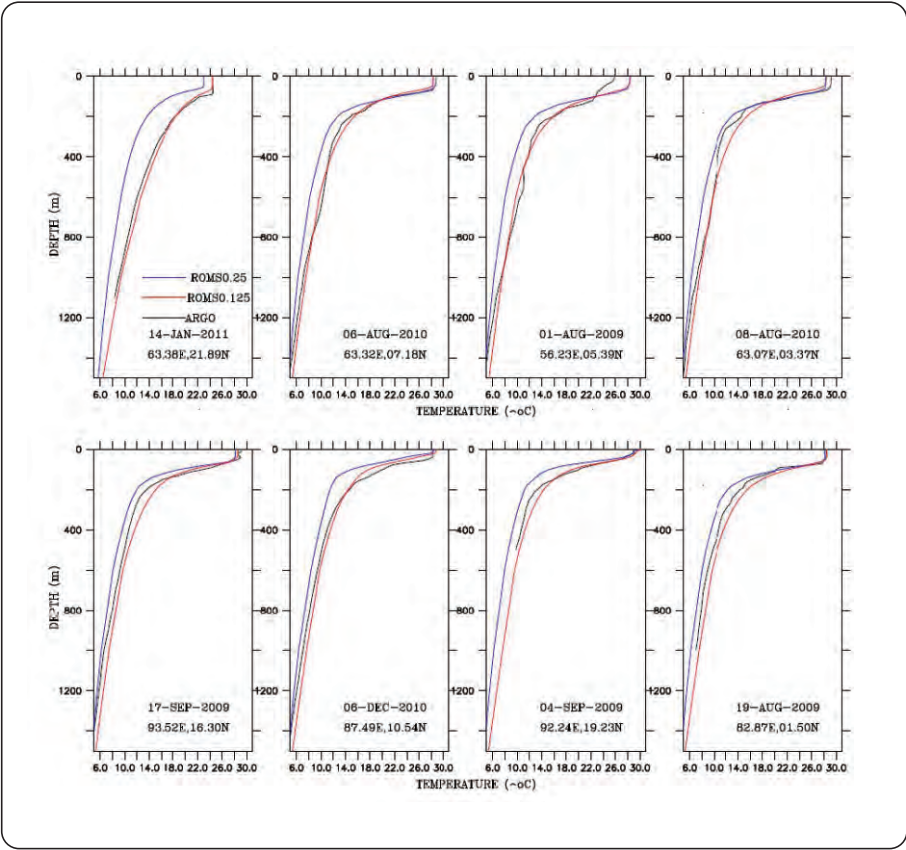
Eighty three tuna fishery advisories were generated and disseminated through maps and text information on Tuesdays, Thursdays and Saturdays. Also initiated a multi-institutional project to tag and study the habitat of Tuna in collaboration with Fishery Survey of India (FSI), Central Marine Fisheries Research Institute (CMFRI) and Central Marine Living Resources and Ecology (CMLRE). The project is expected to provide the necessary information on Tuna habitat and preferred environment that can be monitored using satellite technology. This information will improve the advisories on Tuna fishing grounds.

4.3 Ocean State Forecast

In the arena of ocean forecasting, few new services were initiated while continuing the operational forecast system of ocean circulation features and wind-waves. Indian navy validated the quality of predicted temperature profiles with observations and stated that the forecasts are meeting their requirements.

‘High Wave Alert’, a bulletin, to provide the warnings on risky high waves that might affect the specific locations along the Indian coast was introduced in April 2010, were found to be extremely useful during the passage of cyclone Phet along the coast of Gujarat in 30-May to 7-June 2010 . Similar alerts were issued to Tamil Nadu and Andhra coasts during other cyclones. The high alert information is issued in local languages through web, digital display boards and through emails in local languages.

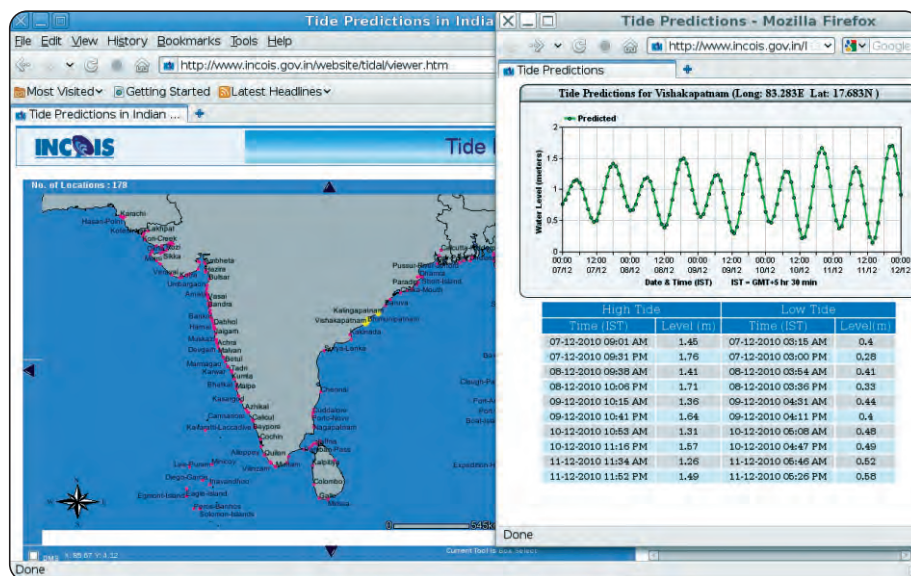
The Indian Ocean Forecast System (INDOFOS), that basically used the Regional Ocean Modeling System, was further improved through the changes in parameterization schemes and increasing the spatial resolution ($\frac{1}{8}^{\text{th}}$ degree ie., $\approx 13\text{km}$). The improved INDOFOS was made operational on 21st March 2011. The improvements significantly improved the quality of the forecasts, particularly in the vertical temperature profiles and surface and subsurface currents. The improved spatial resolution also enabled forecasting up to 75 m water depth rather than 150 m in the earlier setup of $\frac{1}{4}^{\text{th}}$ degree resolution.



Vertical temperature profiles simulated using $\frac{1}{8}^{\text{th}}$ degree resolution INDOFOS setup (red) and the profiles observed by ARGO floats (black). The profiles from previous low resolution INDOFOS setup (blue) also are shown to highlight the improvements.

Another new service launched during the past year was the tide prediction system for Indian subcontinent. This service provides information on predicted ocean tides for next five days at 178 major and minor ports along the coasts of India (136) and neighboring countries (Myanmar-12, Sri Lanka-11, Bangladesh-9, Chagos-5, Pakistan-4 and Maldives-1). The tidal information is routinely disseminated through INCOIS website (as time series plots and High and Low water listings). The tidal constituents necessary to predict the tides were provided by National Institute of Oceanography, Goa.

High resolution wave forecast models were also set up exclusively for Andaman and Nicobar and Lakshadweep group of islands.

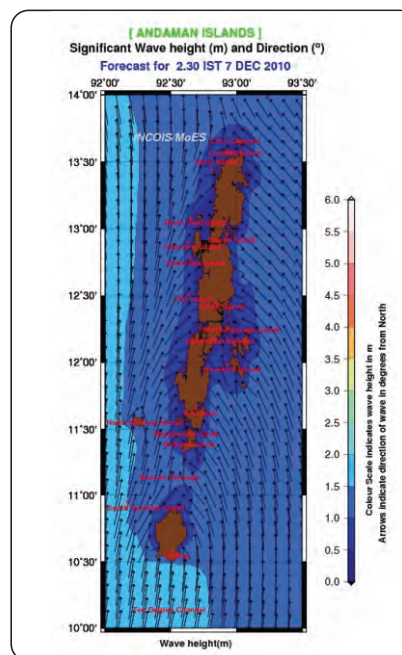


Web interface of tide prediction system at INCOIS.

The forecasts are made available through INCOIS website and digital display boards installed in Andaman & Nicobar Islands and Lakshadweep Islands.

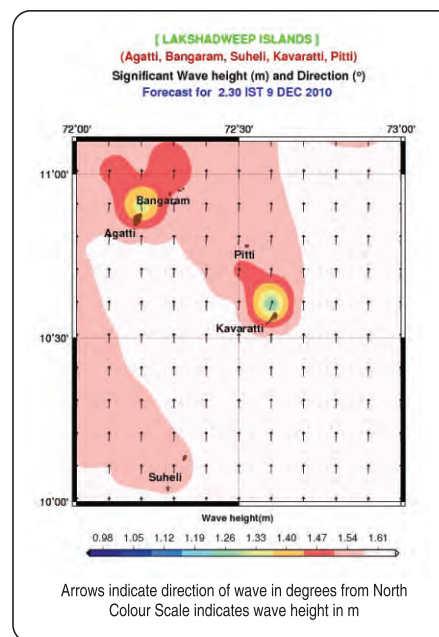


Sri. Vivek Ray, Chief Secretary, Andaman Nicobar, Administration inaugurated the Andaman & Nicobar specific forecasts on 6-August-2010. A sample of Andaman Island specific forecast (right).



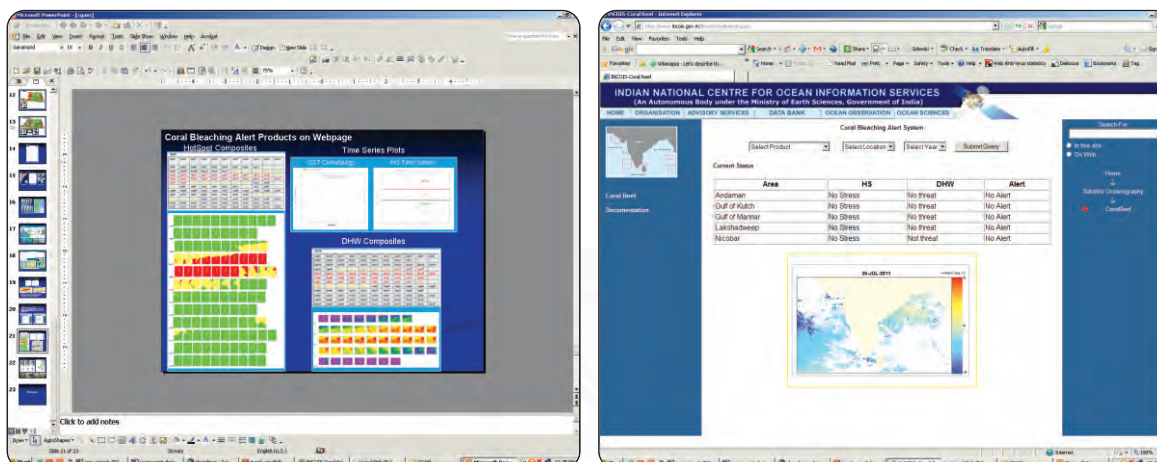


Shri. J. K. Dadoo, Hon. Administrator of Union Territory of Lakshadweep, inaugurated the forecasts for Lakshadweep on 19, November 2010. A sample Lakshadweep specific forecast(right).



4.4 Coral Bleaching Alert System (CBAS)

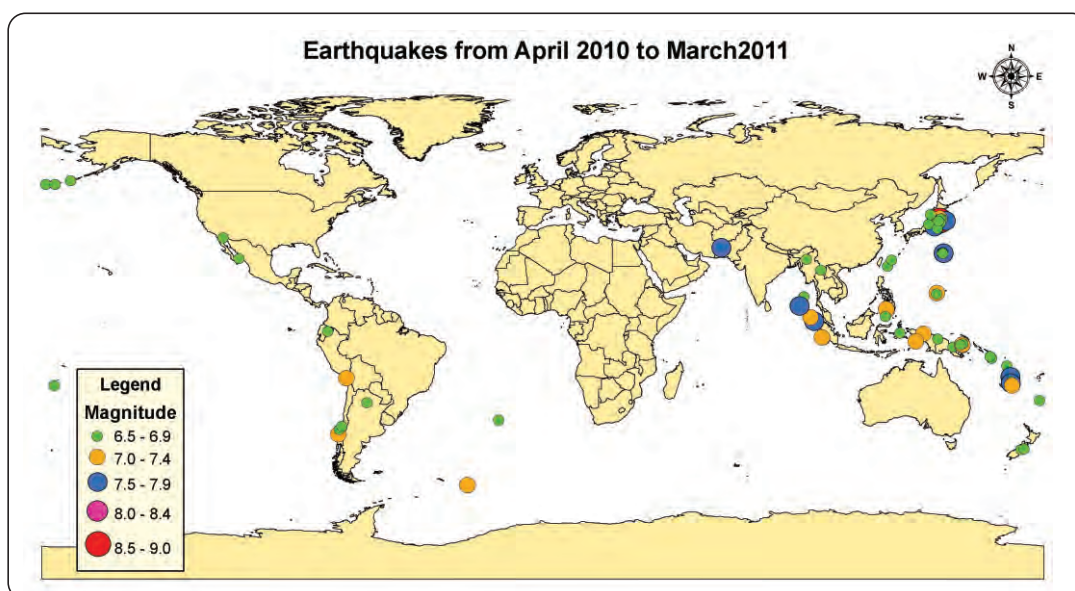
A new service named 'Coral Bleaching Alert system (CBAS)' was made operational on 4 February, 2011. It uses the satellite based night time SST data derived from NOAA-AVHRR for the routine generation of the products. The SST is one of the major factor responsible for the severe bleaching events. The combination of the time series SST climatology with the present SST will provide an indication on the early signs of bleaching. The method developed by NOAA Reef Watch has been adopted after evaluating in the Indian coral environments. The alert has been issued bi-weekly basis. The alert is provided to five coral environments of Andaman, Nicobar, Gulf of Mannar, Lakshadweep Islands and Gulf of Kachchh. This will provide the early signs on the coral environments that undergo thermal stress and the possible intensity of bleaching. The products such as Hot Spot (HS), Degree of Heating Weeks (DHW's) and time-series plots of CBAS were published on the INCOIS website routinely.



CBAS products (left) on the website (right) available via URL: <http://www.incois.gov.in/Incois/coralwarning.jsp>.

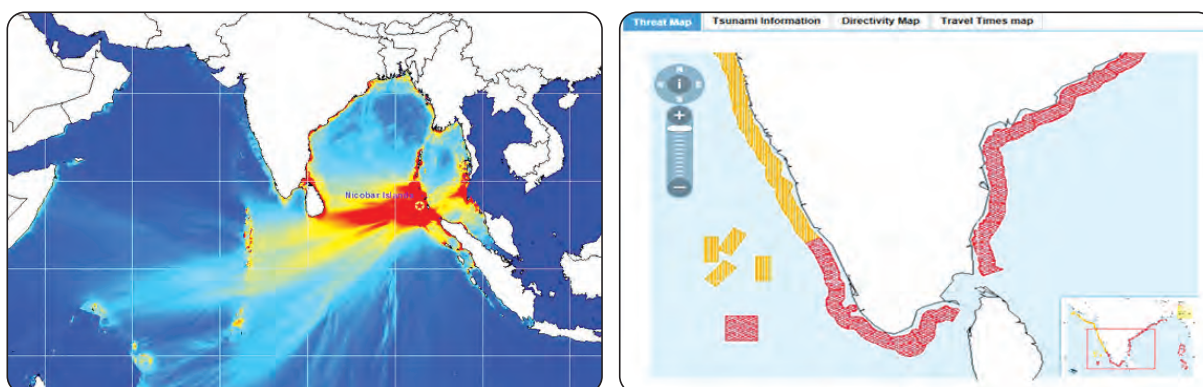
4.5 Early Warning System for Tsunami and Storm Surges

The tsunami early warning centre reported 72 earthquakes of magnitude 6.5 during April 2010 - March 2011. Out of 72 earthquakes for the period April 2010 - March 2011, the centre has issued tsunami advisories for 6 major earthquakes occurred in the Indian Ocean and 1 great earthquake in the global ocean. Model simulations were analyzed for all these events and tsunami bulletins were issued.



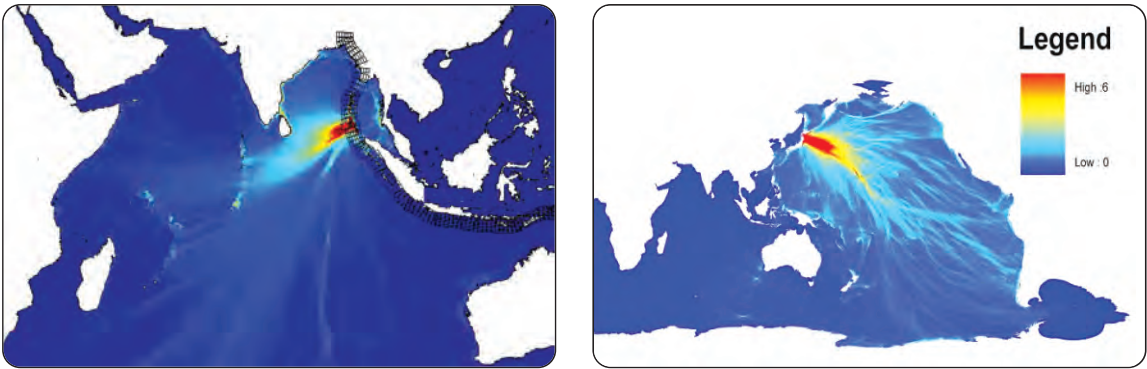
Location of earthquakes of magnitude ≥ 6.5 monitored at the tsunami early warning centre.

One of the major achievement of the centre during the year is the development of an operational Decision Support System (DSS) that can help a tsunami watch operator in making the best possible decisions to issue appropriate bulletins as well the automation of dissemination of bulletins. The DSS generates and disseminates information by multiple modes- emails, SMS, fax GTS as well as through dedicated tsunami website.



Screen shot of the products available on ITEWC Website.

Tsunami advisories for both India and Indian ocean rim countries, along with the threat level maps, directivity maps and travel time contour maps are generated and published automatically. The near real-time data from the tide gauge network & BPR network are also published on the website.



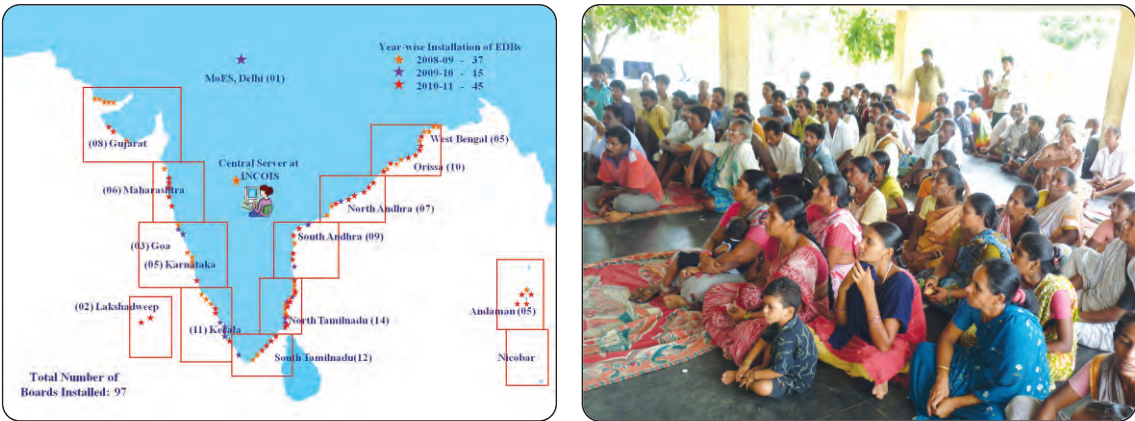
Directivity map of Nicobar Islands earthquake and that of Japan Tsunami.

IOTWS Communication Test:

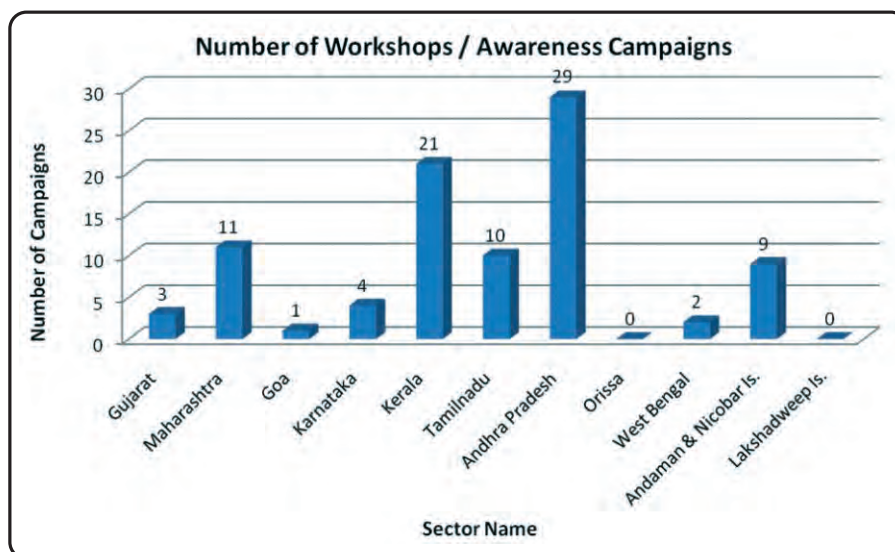
INCOIS participated in the communication test coordinated by IOC/IOTWS on March 16, 2011. The test was aimed at validation of the Regional Tsunami advisory Service Provider (RTSP), dissemination process to National Tsunami Warning Centres (NTWCs), reception of the notification messages by NTWCs and the access by NTWCs to RTWP password-protected websites.

4.6 Dissemination and User Interactions

To enhance the reachability of PFZ and OSF products to a wider section of population along the Indian coast, INCOIS installed forty two new generation Electronic Display Boards (EDB) in Andhra Pradesh, Tamil Nadu, Puducherry, Maharashtra and Andaman islands, during the past year replacing the old type boards. Other modes like electronic display boards (97), information kiosks(28), Doordarshan, print media, emails (276), mobiles (2001), website (Text: 9151 Users; WebGIS:1214) and telephone and Fax (141), were also used for the dissemination effectively.



Number of EDB installations along the Indian coast. A Fishing community gathering during EDB inauguration event (right).



Number of awareness campaigns conducted in each state during 2010-11.

Ninety one user interaction workshops were conducted to train the fishermen on how to read and use the PFZ and OSF information at various panchayats in the coastal districts.



A meeting with the representatives of NODPAC, ONGC, Coast Guard, NGOs on OSF products on 29 November 2010 at INCOIS. The users shared their experience with OSF products and suggested modifications based on their specific requirements.



A meeting with the officials of Pondicherry Multipurpose Social Service Society and Catholic Relief Society at INCOIS on 11-08-2010. The meeting discussed on how to improve on the dissemination of PFZ, OSF information and tsunami warnings among the coastal communities.

For the first time since the inception of INCOIS, a combined user interaction workshop was conducted on 4 February, 2011 at INCOIS with the participation of 175 users of PFZ, OSF and other data products collated at INCOIS.



The first combined user meet at INCOIS.

5. Observation Networks

5.1 Indian Argo Project

The observation network managed/coordinated by INCOIS continued to return data from various platforms. 31 Argo floats were deployed in the Bay of Bengal, the Arabian Sea, and in the Equatorial Indian Ocean. Three Argo floats fitted with oxygen and chlorophyll sensors, provided by University of Washington, were also deployed in the southeastern Arabian Sea. These floats deliver data at every 2.0 m of upper water column.

5.2 Other Ocean Observing Systems

The cone-head buoy that was deployed in the Bay of Bengal an year ago was recovered successfully. The data on temperature, salinity and currents in the upper 100 m of the water column is expected to provide important information on circulation, heat and freshwater balance, and air-sea interaction on diurnal to seasonal scales in the Bay of Bengal. Other observing systems deployed during 2010-2011 are given in Table below

Platform	Activity	Location	Number
Drifting Buoys	Deployment	Arabian Sea & BoB	24
XBT/XCTD	Deployment	Indian Ocean	268/87
Current meter Moorings	Servicing	Eq. Indian Ocean	7
ADCP- Moorings	Re-deployment	Indian Ocean	8
Rama Moorings	Service	Indian Ocean	14
Tsunami Buoys	Deployment	Bay of Bengal	1
Directional wave rider buoy	Service/Deployment	Near Karwar coast	5
Remote wave height meter	Installation	Sagar Nidhi	1
Sediment trap	Deployment	Eq. Indian Ocean	1
Automatic Weather Stations (AWS)	Deployment	Research vessels	5
Sea level gauges/tide gauges	Installation	Along the Indian coast	21

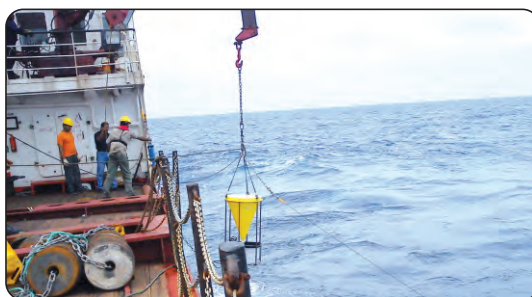
Observational platforms deployed/serviced during 2010-2011.



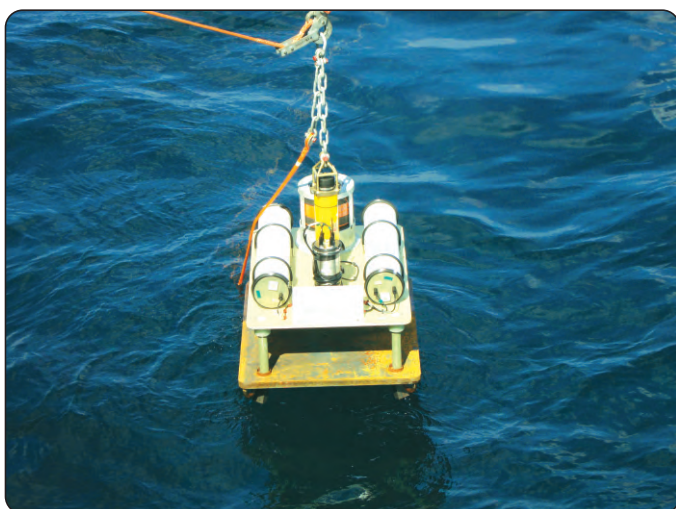
SAIC tsunami buoy deployed in the Bay of Bengal (left) and a Wave rider buoy being deployed in the coastal waters (right).

Automatic Weather Station Network:

To widen the observational network of surface met-ocean parameters, INCOIS completed the installation of Automated Weather Stations (AWS) on board the ships owned by MoES. The AWS are equipped with sensors to measure wind speed, wind direction, long-wave and shortwave radiations, air temperature, humidity, surface pressure, rainfall and sea surface temperature and report the data in real time to INCOIS via INSAT.



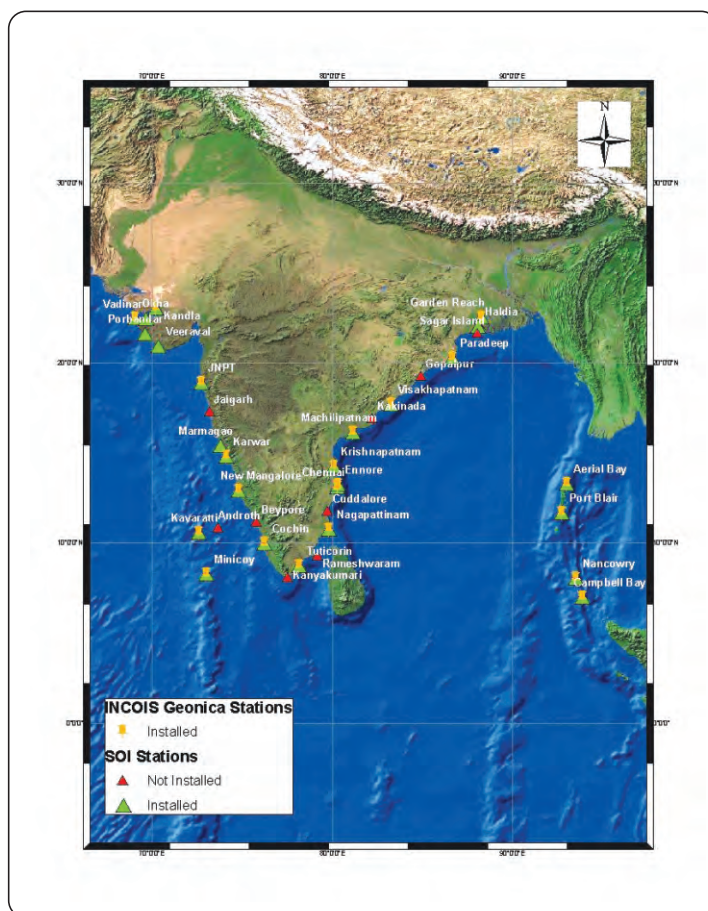
AWS on board Sagar Kanya (left), Deployment of Sediment trap from Sagar Kanya (middle), Wave height meter on board Sagar Nidhi (right).



*Deployment of the SAIC tsunami buoy in the Arabian Sea
Bottom Pressure Recorder: Left and Surface Buoy: Right.*

Bottom Pressure Recorder (BPR) Network:

The bottom pressure recorder (BPR) or tsunami buoy deployed in the Bay of Bengal (STB01) in April, 2010 continuously transmitted data to Indian Tsunami Early Warning Centre (ITEWC). A second BPR was deployed in the northern Arabian Sea (STB02) in December 2010. Data from both buoys are received continuously at ITEWC. The centre is also receiving data from two more tsunami buoys (TB05, TB08) deployed by NIOT in the Bay of Bengal. Apart from the Indian buoys, data from 3 international buoys deployed in the Indian Ocean are also being received at INCOIS.



Location map of INCOIS - SOI tide gauge stations along the coast of India.

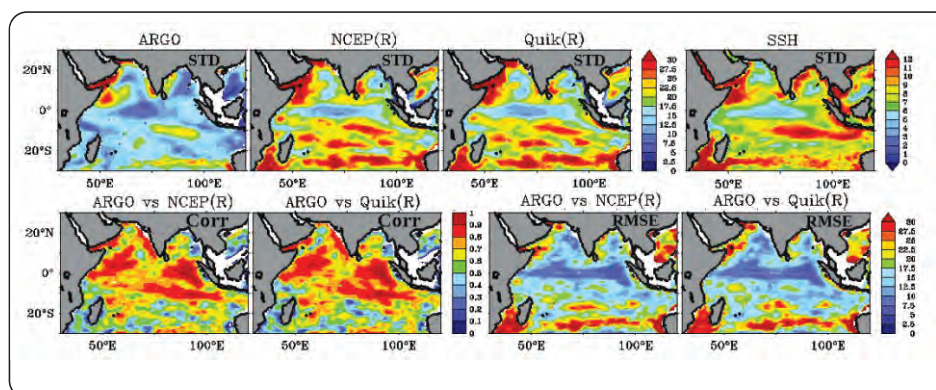
Tide Gauge Network:

In collaboration with SOI, INCOIS installed tide gauges at 21 locations along the Indian coast. For tsunami warning redundancy purpose, each station is equipped with three sensors namely, float-shaft encoder, acoustic radar sensor and pressure sensor. Continuous data from all stations are being received at the warning centre through three communication systems - VSAT, INSAT and GPRS. The tsunami warning centre also receives continuous data from 68 international tide gauges located along the coasts of the Indian Ocean in near real-time through internet.

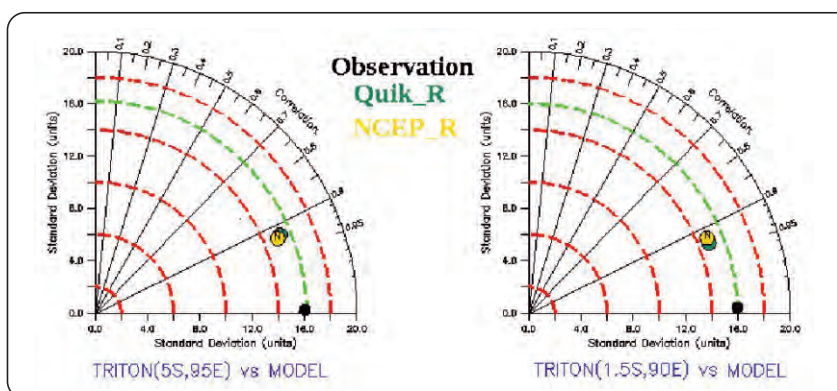
6. Research and Modelling

6.1 GODAS Assimilation System

Global Ocean Data Assimilation System (GODAS) obtained from NOAA/NCEP was successfully ported on INCOIS HPC. The model domain extending from 75° S to 65° N has a resolution of 0.5° zonally and, 0.25° in tropics meridionally. The model has 40 levels with a 10 meter resolution in the upper 200 meters. At present the temperature and salinity profiles from in-situ observations (Argo Profiling floats, XBT and moorings such as RAMA, PIRATA, TAO) over global ocean have been assimilated to produce the best analysis products. The model is being tested with NCEP and QuikSCAT winds. The analysis shows that the GODAS-MOM simulation forced with NCEP and QuikSCAT wind forcing are reasonably simulating the thermocline.



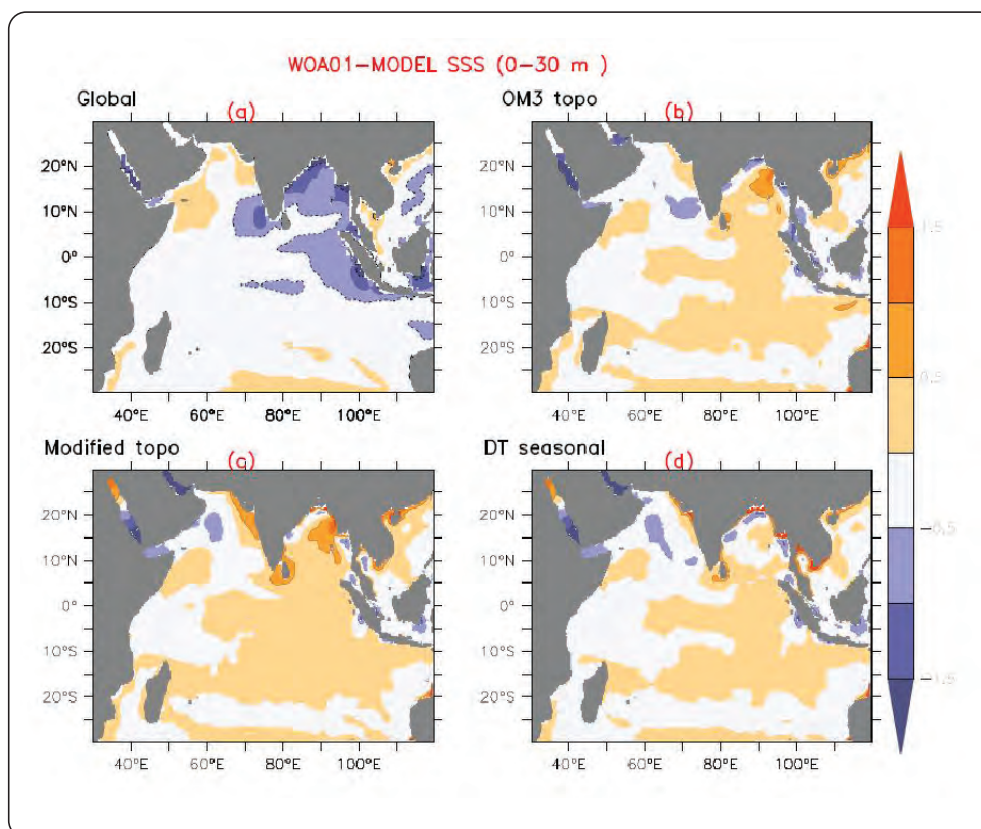
Standard deviation (2004-2008) of D20 from ARG0 data, NCEP run, QuikScat run and SSHA (Top panel). Correlation between D20 of ARG0 vs NCEP run, Correlation between D20 of ARG0 vs QuikSCAT run, RMSE between D20 of ARG0 vs NCEP run, RMSE between D20 of ARG0 vs QuikSCAT run (Bottom panel).



Taylor diagram comparing D20 from QuikSCAT run, NCEP run and observation from TRITON buoy location 5° S, 95° E (left) and 1.5° S, 90° E (right) in the equatorial Indian Ocean. The plot summarizes the correlation and standard deviation of each QuikSCAT run (green circle) and NCEP (yellow circle) run with respect to observation (marked as black circle in the X-axis).

6.2 Development of $0.25^\circ \times 0.25^\circ$ Regional Indian Ocean Model using MOM4p1

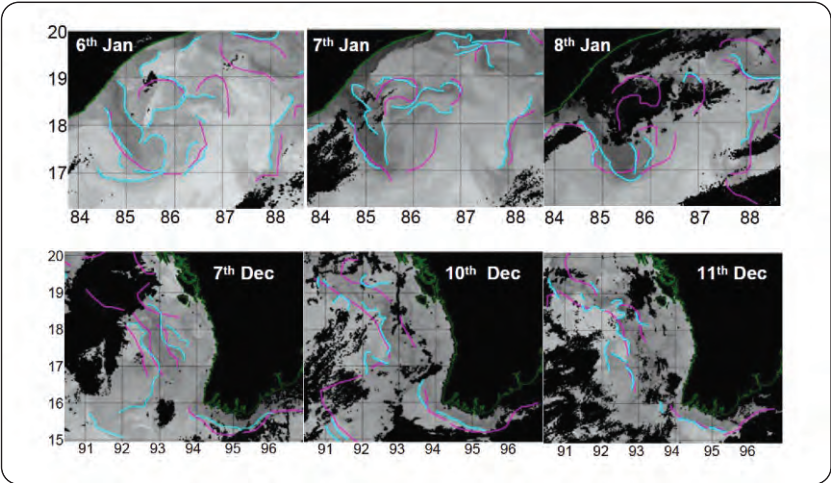
A Quarter degree regional Indian Ocean model, Modular Ocean Model (MOM4p1) have been developed and setup with lateral boundary conditions are taken from inter-annual solutions from global model forced with Co-ordinated Ocean Ice Reference Experiments (CORE- II). The improved topography and seasonal runoff improved the surface salinity bias to 0.2-0.3 psu over the north Indian basin, similarly there is significant improvement in subsurface salinity and temperature, as well as the mixed layer depth. The upper ocean circulation also showed improvements.



Upper Ocean (0-30M) Sea Surface Salinity annual difference plot from WOA01 observations (a) Global model with annual river runoff (b) Regional model with OM3 topo (global model) and annual river runoff (c) Modified ETOP05 with annual river runoff (d) Modified ETOP05 with Dia and Trenberth (2002) seasonal river runoff.

6.3 CUPOM

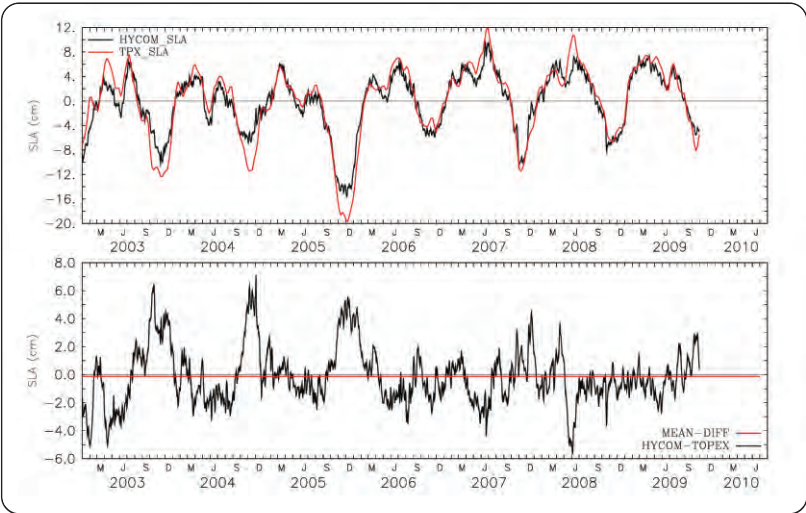
The CUPOM OGCM with limited data assimilative capability was set up at high resolution ($1/16^\circ \times 1/16^\circ$) to simulate the SST to provide high resolution SST for PFZ applications. The high resolution SSTs simulated using CUPOM was successful in generating about 60% of the PFZ features in the coastal waters.



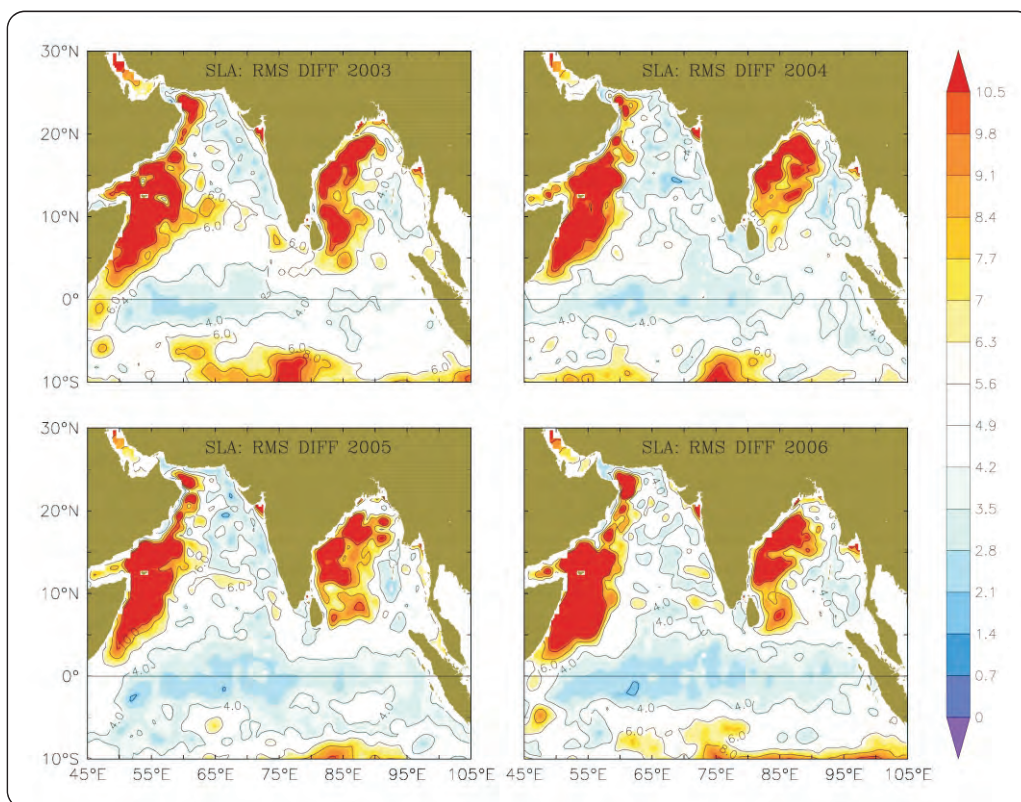
Typical snapshot of PFZ features generated using AVHRR and CUPOM SST.

6.4 Hycom

Hycom 2.2.27 was configured on the HPC at INCOIS and has been used to simulate Indian Ocean on inter-annual timescales using NOGAPS winds for the period of 2003 to 2010. The model could simulate the sea level with an RMS less than 7 cm over most of the region.



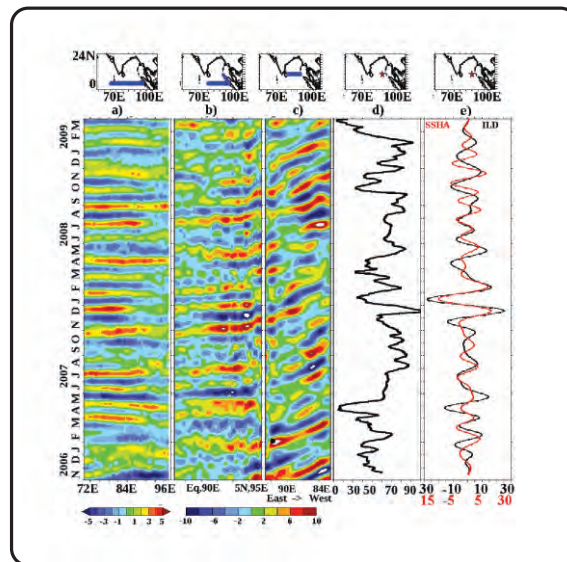
Time series of Hycom altimeter SLA in a box bounded by 60° to 70°E and 2° to 10°N;
Correlation =0.95, RMSE= 2.3 cm and skill score = 0.88.



Spatial RMSE of Hycom simulated sea level anomalies against altimeter derived sea level anomalies.

6.5 Research Findings During 2010-2011

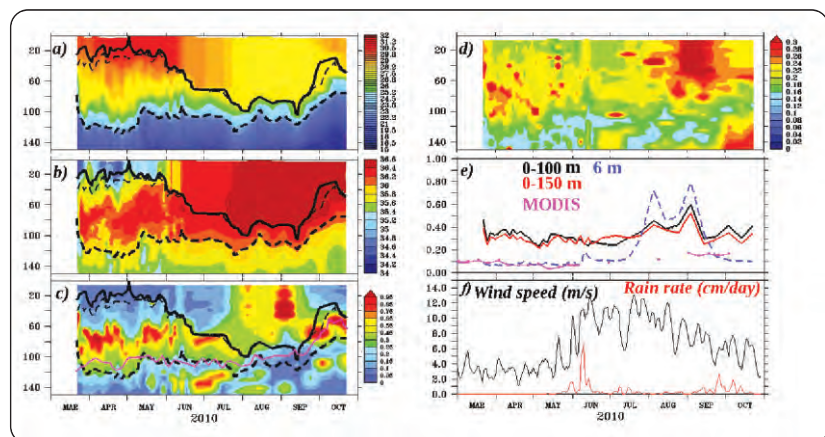
Intra-seasonal variability in Barrier Layer: The thickness of barrier layer that forms due to the presence of fresher water in the upper layers of the ocean is an indicator of the mixing processes in the upper ocean. The Barrier Layer Thickness (BLT) in the central Bay of Bengal was found to have large intra-seasonal variability mainly controlled by the vertical movement of Isothermal Layer Depth (ILD) in the presence of a shallow mixed layer. Both ILD and BLT were modulated by the vertical stretching of upper water column associated with the westward propagating intra-seasonal down-welling/upwelling Rossby waves in the southern bay indicating that the ocean dynamics plays an important role in the upper ocean heat balance, specially through formation of thermal inversions below the mixed layer (Girishkumar et.al, Journal of Geophysical Research 2011).



Time longitude plots of 40-100 day band pass filtered (a) zonal wind (m/s) along the equator, (b) SSHA (cm) at equator and off Sumatra coast (c) SSHA (cm) along 8 N in the southern Bay of Bengal and (d) time series of ILD (m) (not filtered) at 8N 90E location. (e) time series of 40-100 days band pass filtered ILD (m) and SSHA (cm) at 8N 90E.

Analysis of Chlorophyll-Maxima:

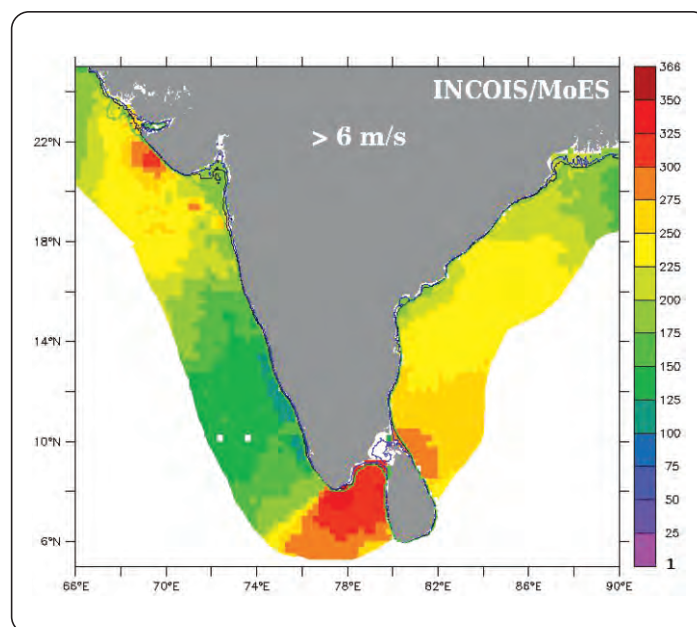
The time series of temperature, salinity, chlorophyll *a*, particle scattering at 700 nm, and dissolved oxygen obtained by Argo float, deployed in the south eastern Arabian Sea shows the occurrence of subsurface chlorophyll *a* maxima around 80 m depth during March-June 2010, just above the top of thermocline and oxycline. Later the intense wind induced mixing during summer monsoon brings the subsurface maxima to the near surface layer leading to surface bloom. The occasional intensification of surface blooms during the first week of August and September, 2010, in the presence of low rain/clear sky condition are all well recorded (Ravichandran et. al, submitted to Deep Sea Research).



Depth time section of (a) temperature (b) salinity (c) chlorophyll *a* (d) particulate backscattering at 700 nm. (e) Temporal evolution of chlorophyll *a*, average 0-100 m (black), 0-150 m (red), at depth 6 m (blue) and derived from MODIS (pink). (f) Daily evolution of TRMM TMI wind speed and rain rate from Argo float 1. The thick, thin dashed and thick dashed lines represent mixed layer depth, isothermal layer depth and depth of 23° isotherm. In the panel (c) pink lines indicates the 20µM dissolved Oxygen concentration from Argo float 2.

Wind Energy Potential Along the Coast of India:

Off-shore wind farming is being considered as an alternate source to meet the energy requirements of the country. Considering its importance, an atlas was prepared based on the 10 years data of QuikSCAT winds. The in situ data available from the moored buoys were used to apply the necessary corrections to the satellite data. The atlas indicates the number of days on which the wind speed exceeds different thresholds (6.0 m s^{-1} , 8.0 m s^{-1} , 10.0 m s^{-1} , etc.). Coast of Tamil Nadu near Tuticorin, and the coast of Gujarat has the maximum number of windy days. (Harikumar et.al INCOIS Report No.: INCOIS-MOG & ISG-OSF-TR-2010-01, 2010).

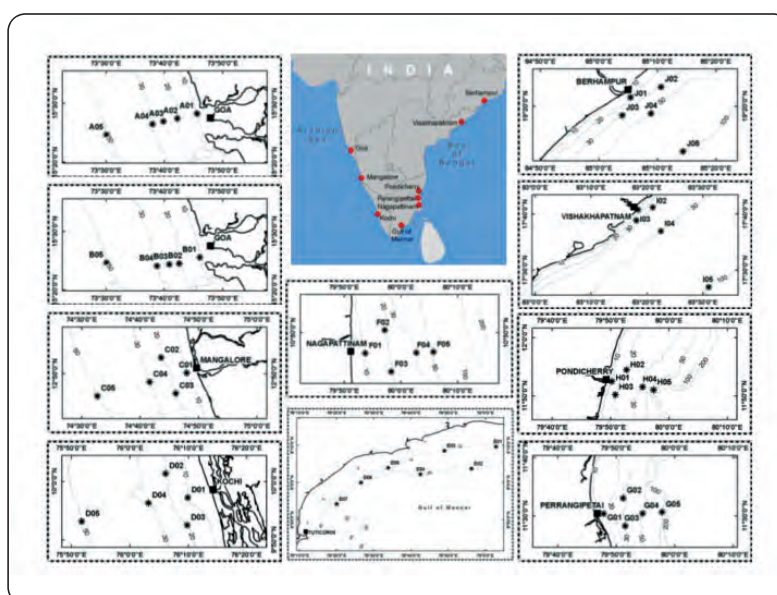


The daily climatological maps of wind exceeding 6 ms^{-1} (colour scale indicates number of days). The 10 m (blue line), 20 m (black line) and 30 m (green line) depth contours are also shown.

7. Satellite Coastal and Oceanographic Research

Time Series Measurements:

While continuing the timeseries measurements along nine transects in the Indian coastal waters, one more transect in the Gulf of Mannar was added to Satellite Coastal and Oceanographic Research (SATCORE) network. The in situ data generated at one of the SATCORE station, off Kochi, was used to validate ocean color products from Envisat MERIS-ENVISAT and MODIS-AQUA satellites. The results indicated better accuracy for MODIS-AQUA as compared to that from MERIS-Envisat. The validation results, based on 11 statistical indicators, showed that MODIS-AQUA default algorithm performs better in the study area.

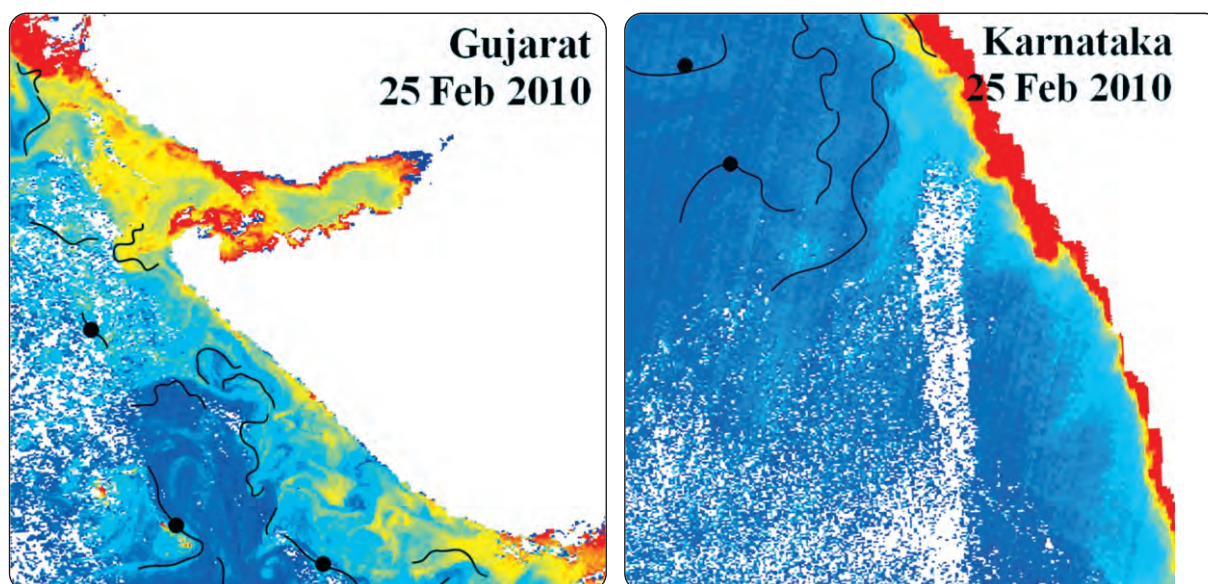


SATCORE Network. The location of time series stations are indicated with black dots.

Ocean Colour Products:

The Automatic Data Processing Chain (ADPC) setup to process the satellite based ocean colour data was further enhanced by incorporating the ability for domain scaling, spatial resolution scaling and addition. The set up also supports the SeaWiFS Data Analysis System (SeaDAS) software. OCM-2 processing was also added in the ADPC along with MODIS-Aqua. Three new standard products, namely, Quasi True Colour Composite (QTCC), CDOM index and Aerosol Optical Thickness (AOT), were added in ADPC. The ADPC is now capable of producing 3 day, 7 day, 30 day standard rolled products as well as 30 days rolled anomaly products of chlorophyll and Sea Surface Temperature (SST). ADPC is also used to produce the new products namely, Total Suspended Matter (TSM) and Bloom Indices (BI).

A conceptual frame work was designed, using outputs from ADPC, for detection and monitoring of Harmful Algal Blooms (HABs). The proposed methodology integrates the three bloom indicators: BI, Rolling Chlorophyll - a Anomaly (RCA) and SST anomaly.



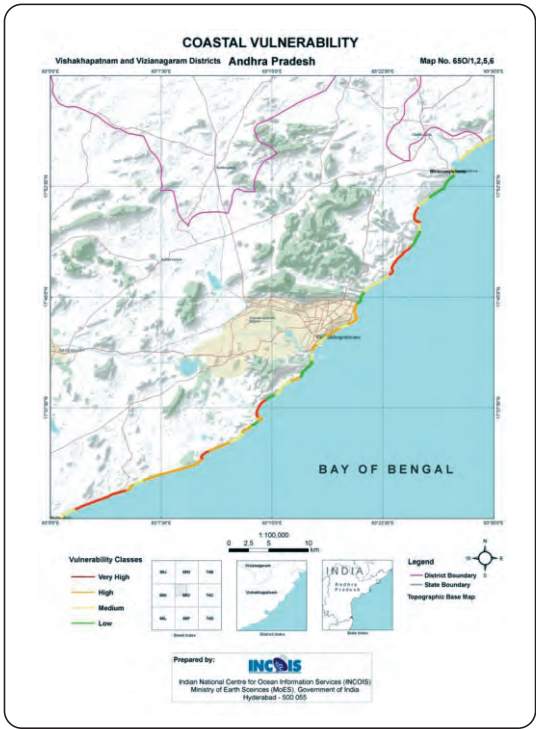
Chlorophyll-a imageries generated from OCM-2 data overlaid by PFZ lines identified from MODIS-Aqua data. The black dot indicates feature identified from SST gradient.

Validation of Ocean Colour Monitor (OCM) Data:

The data products from Ocean Colour Monitor OCM-2 were evaluated for the generation of PFZ advisories. The evaluation was carried out by comparing Chl-a generated from OCM-2 and MODIS-Aqua (MODISA) and SeaWiFS. After applying the new gain coefficient, substantial improvement was observed in the detection of Chl-a fronts from OCM-2 data. The PFZ lines generated using MODISA data were in good agreement with those generated using OCM-2 data. The magnitude of Chl-a from OCM-2 matched well with MODISA and SeaWiFS data in the range of 0.5 to 1.0 mg m⁻³. However in the low Chl-a (< 0.5 mg m⁻³) zones OCM-2 overestimated as compared to MODISA and SeaWiFS.

Coastal Vulnerability Indices:

Completed the preparation of Coastal Vulnerability Indices (CVI) maps for the entire coastline of India at 1:100000 scale. The CVI was estimated using the seven basic parameters, namely, shoreline change, geomorphology, coastal elevations, coastal slope, sea-level change rate, mean significant wave height and tidal range. The CVI maps indicate the degrees of vulnerability of the coastline due to the combined effects of aforementioned parameters. The maps are expected to serve as a good visual tool in decision making in delineating areas of dynamic changes due to various physical processes.



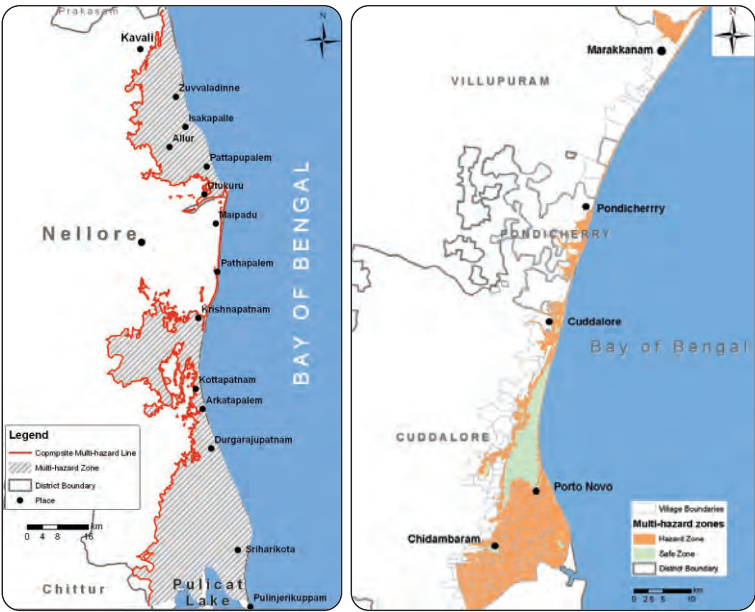
CVI map of a stretch of Andhra Pradesh coast.

No.	State	No. of Sheets
1	West Bengal	8
2	Orisa	12
3	Andhra Pradesh	20
4	Tamil Nadu	19
5	Kerala	15
6	Karnataka and Goa	9
7	Maharastra	12
8	Gujarat	30
9	Andaman and Nicobar Islands	21
10	Lakshadweep Islands	11
	Total	157

Number of Coastal Vulnerability maps prepared along the Indian coast.

Multi-hazard Vulnerability Mapping:

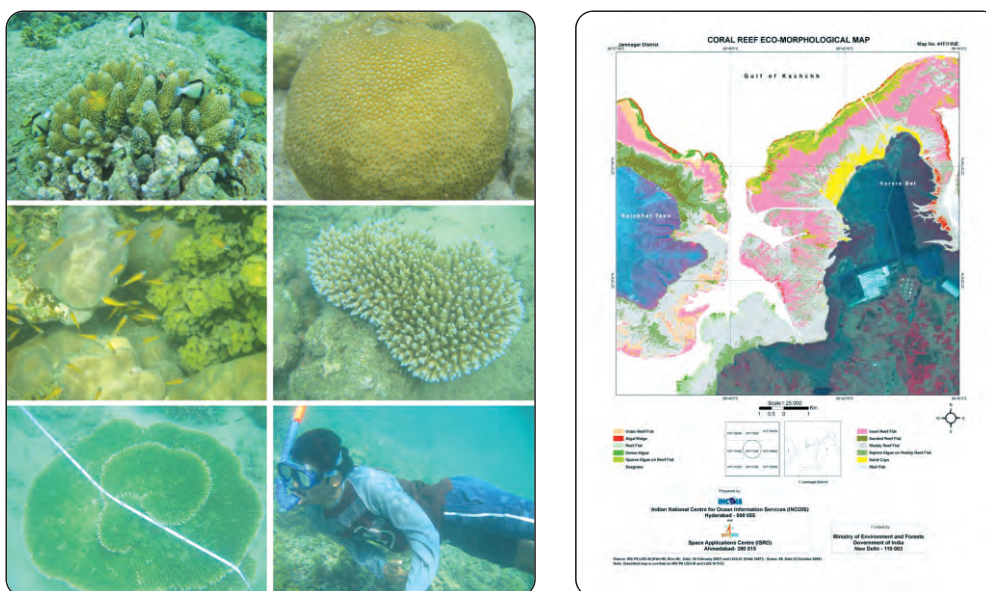
Water levels recorded by tide gauges, sea level change, shoreline change and high resolution topography were the parameters selected for mapping. The additional parameters such as land-use, buildings, roads etc are also used to generate the risk maps and evacuation planning. A pilot study to map the multi-hazard vulnerability (due to changes in sea level and shoreline) was carried out for the coastal stretches of Nellore, Andhra Pradesh and Cuddalore, Tamil Nadu. The multi- hazard vulnerability mapping identifies the vulnerable regions due to natural hazards.



Multi-hazard vulnerability maps for Nellore (left), and Cuddalore (right).

Eco-morphological Zonation of Coral Reefs:

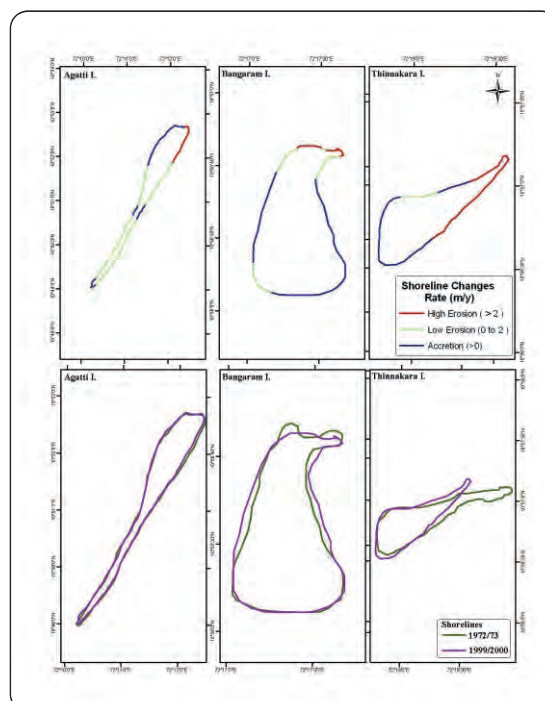
Completed the mapping and database generation of coral eco-morphology for Andaman and Nicobar, Gulf of Kutch, Gulf of Mannar and Malvan reef regions. An atlas of the coral eco-morphology comprising 156 maps was prepared.



Field photos of coral species (left) and a sample map from the coral eco-morphology atlas (right).

Shoreline Change Studies of Lakshadweep Islands:

Data from Landsat MSS, TM and IRS-P6 LISS-III were used to assess the rate of change of shorelines along the Lakshadweep Islands over the past 35 years pertaining to the period 1972/73 to 2007/08. Kiltan Island underwent severe erosions at a rate of 5 m yr^{-1} along the northwestern and southern parts. Whereas Kadamat and Amini Islands underwent the least changes ($< 2 \text{ m yr}^{-1}$).



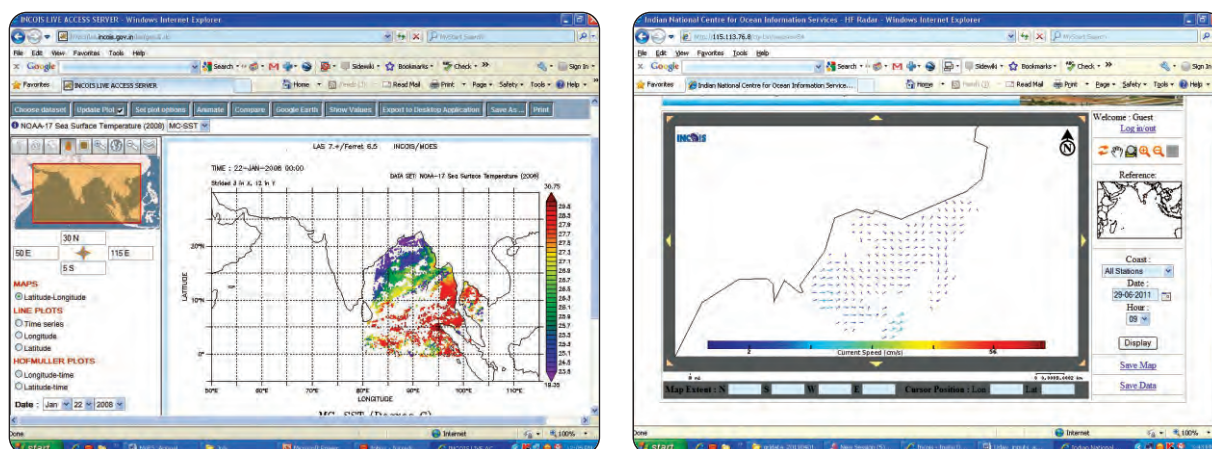
Maps showing the shoreline changes in the Agatti, Bangaram and Thinnakara Islands during 1972/73 to 2007/08.

8. Indian Ocean Modelling and Dynamics (IN-DOMOD)

A Total of 25 projects were funded to the PI's from various institutions and universities, namely, Indian Institute of Science, Bangalore, Indian Institute of Technology Delhi, Indian Institute of Technology, Kharagpur, National Institute of Oceanography, Goa, Centre for Mathematical Modelling and Computer Simulation, Bangalore, Andhra University, Visakhapatnam, Hyderabad University, Hyderabad, Cochin University of Science and Technology, Kochi, Annamalai University, Chennai, Jadavpur University, Jadavpur, and Alla-habad University, Allahabad. From these projects, twenty two papers were published in peer-reviewed national/international journals during the year 2010-11.

9. Ocean Data Management and Dissemination

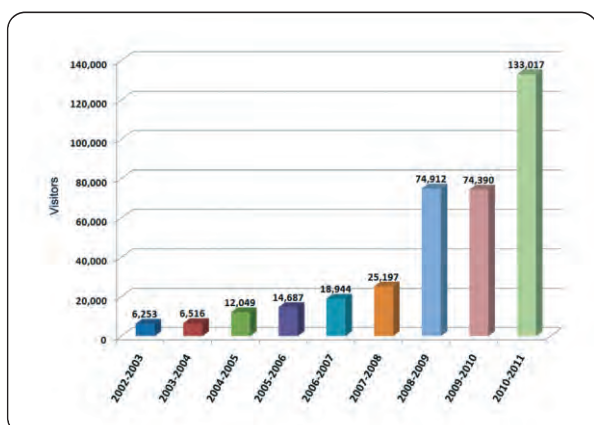
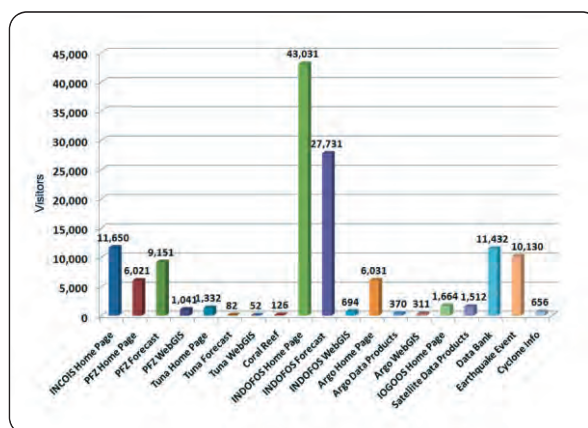
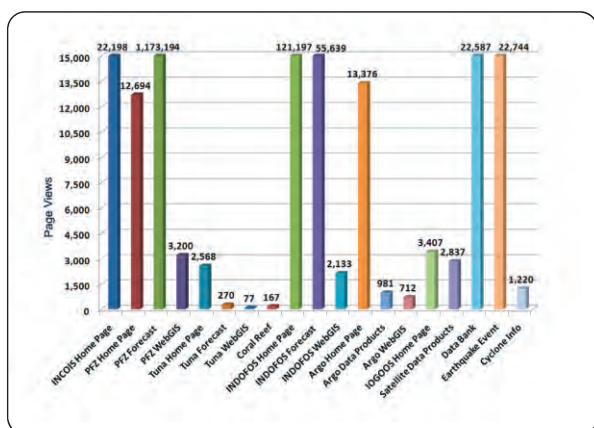
Ocean Data and Information System (ODIS) is further strengthened by integrating HF Radar data in real-time and connectivity to receive the surface meteorological and oceanographic data from the RAMA moorings in real-time. Live Access Server (LAS) at INCOIS was enhanced with the addition of new weekly OCM Chl *a* climatology prepared at INCOIS, MLD climatology using the temperature-salinity data from Argo floats, daily pass of Chl *a* from MODIS and daily pass of MCSST from NOAA AVHRR. Also developed a new product to identify the fog from AVHRR and MODIS data on a special request from India Meteorological Department.



A snap shot of OCM Chlorophyll a weekly climatology and HF radar data on LAS server at INCOIS.

10. Web Services

There was a phenomenal growth ($\approx 58\%$) in the number of national and international visitors/users who accessed the INCOIS web during the past years.



Web statistics of INCOIS [service vice (top 2 panels)] and growth over past financial years (bottom).

11. Infrastructure

Major Communication Installations at INCOIS During 2010-2011:

- Interface of INSAT MSS transmitter with wave height meter for real time reception of data at INCOIS hub station.
- Initiated the work under phase II expansion of campus. The phase II expansion comprises of construction of an additional floor/s for the main building and amenity building of INCOIS, construction of residential accommodation for the staff, guest house, construction of compound wall for the newly acquired land, lake strengthening, etc.

12 General Information

12.1 International Collaboration

ChloroGIN:

The ADPC established at INCOIS continued to supplement the global initiative Chlorophyll Global Integration Network (ChloroGIN). The ocean colour data was generated daily from MODIS-Aqua and disseminated at near real time to Indian ocean rim countries: Sri Lanka, Iran, Kenya, Maldives, Oman, Tanzania and Thailand. An agreement was also signed with European Space Agency (ESA) for coast colour project. The major objective of the coast colour project is to develop, demonstrate, validate and inter-compare different case 2 algorithms over a global range of coastal water types.

Indian Ocean GOOS (IOGOOS):

The IOGOOS secretariat functioning at INCOIS since its inception in 2002 facilitated several collaborative projects between the member institutions. The IOGOOS membership has grown from 19 to 26 institutions representing 14 countries. The annual meeting IOGOOS held in Perth, Australia extended the functioning of IOGOOS secretariat at INCOIS upto 2013 and also elected Indian representation to one of its officers position and the IRF forum elected Dr. Shailesh Nayak, secretary, MoES as the founder chairman.



7th Annual Meeting of IOGOOS held at Perth, Western Australia during 12-16 July, 2010.

12.2 Meetings/Workshops Organized by INCOIS

1. INCOIS organized a five day training course jointly with SDMC on “Early Warning System for Hydro-Meteorological Disasters” during August 16-20, 2010 for SAARC member countries. 25 members from India, Pakistan, Maldives, Sri Lanka, Afghanistan, Bangladesh, Nepal, Bhutan participated in the training.



Participants in the training program on Early Warning System for Hydro-Meteorological Disasters at INCOIS.

2. To improve the professional skills of project Principal Investigators(PI's) and the research scholars, two training workshops were organized. The first one was on "Logistical Framework Approach (LFA)", conducted at Andhra University on April 27, 2010 and the second was on "Spectrophotometric and fluorimetric techniques for water sample analysis". Both programs were conducted at Centre for Studies on Bay of Bengal (CSBoB), Andhra University, during April, 29-30, 2010.



Participants at Logistical Framework Approach (LFA) workshop.



Training on "Spectrophotometric and fluorimetric techniques for water sample analysis".

INCOIS hosted the NTWC training workshop in Hyderabad during February 8-9, 2011 as part of the Inter session meetings of ICG/IOTWS. RTSPs of Australia, India and Indonesia provided training to about 37 participants from 21 NTWCs in the Indian Ocean and familiarized them with the RTSP procedures and services. A desktop exercise was also organized as part of this training for providing hands-on experience to the NTWCs.



NTWC training workshop at INCOIS, during February 8-9, 2011.

- INCOIS Organized a public lecture series in association with Asia Oceania Geo-sciences Society (AOGS) annual meeting held during 6-9 July 2010.



AOGS public lecture.

12.3 Distinguished Visitors

- Sri. Prithviraj Chauhan, Honorable Minister of State for the ministries of Ministry of Science and Technology, Ministry of Earth Sciences, Ministry of Personnel, Public Grievances and Pensions, Ministry of Parliamentary Affairs and in charge of Prime Minister's Office visited INCOIS on July 5, 2010.



Sri. Prithviraj Chauhan, Honorable Minister, visiting INCOIS.

- 12th foundation day of INCOIS was celebrated on 3rd February, 2011 with the foundation lecture on “The Unending Quest for Water Wisdom” by Prof. S. K. Tandon, Ex. Pro-vice Chancellor, University of Delhi. The foundation lecture was followed by cultural program and community dinner for INCOIS family.



Prof. S. K. Tandon, University of Delhi delivering lecture at INCOIS.

3. Parliamentary standing committee on science & technology, environment and forests, visited INCOIS on 16th February, 2011.



Parliamentary standing committee visiting INCOIS.

12.4 Symposia and lectures

The distinguished visitors delivered the following lectures at INCOIS:

1. "Variability and Changes in Ocean Salinity, Circulation, and Temperature due to the Influence of Atmospheric and Riverine Freshwater Fluxes" by Prof. Vikram M. Mehta, (ICCSIR) Ahmedabad on 9 August 2010.
2. "Monsoons, HABS, Pathogens, Swine flue: Prospectus for prediction by Raghu Murtugudde, Professor, University of Maryland on 30 September 2010".
3. "Climate Variability and the Indian Ocean Biogeochemistry" by Raghu Murtugudde, Professor, University of Maryland on 1 October 2010.
4. "Usefulness of time series records in the ocean" by Prof. R Ramesh, Physical Research Laboratory (PRL), Ahmedabad on 12 January 2011.
5. "Data assimilation and related topics" by Dr. Ortega Christain, CLS France on 21 March 2011.
6. "Predictions of the Indian Summer Monsoon Rainfall: Probabilistic and Deterministic" by Prof. Sulochana Gadgil, Hon. Professor, CAOS, Indian Institute of Science, Bangalore, on March 22, 2011.

12.5 Awards

1. The Indian Tsunami Early Warning centre of INCOIS received the PC Quest Award for Best IT implementation for the year of 2010.

2. Tsunami early warning system project of INCOIS was awarded the Web Ratna-09 Platinum award of excellence in e-Governance initiatives under the category of innovative use of technology. This award was instituted by Department of IT and communications, Government of India.
3. Tsunami Warning System Project of INCOIS came up as a Finalist for the Nasscom Social Innovation Honours 2010 Award.
4. Sri. E. Pattabhi Rama Rao received Indian National Geospatial Award 2010 from Indian Society of Remote Sensing (ISRS), for significant contributions in the field of applications of geo-spatial technology for ocean data management.



Sri. Pattabhi Rama Rao receiving the award from Dr. R. R. Navalgund, President, ISRS & Director, Space Applications Centre, ISRO.

5. Dr. Francis P. A. was awarded merit certificate in the category of ocean sciences on the occasion of foundation day celebrations of the Ministry of Earth Sciences held on 27 July 2010. He received this citation in recognition to his contributions in setting up the Indian Ocean Forecasting System (INDOFOS).



Sri. Prithviraj Chavan, Minister of state for the Ministries of Science and Technology, Earth Sciences, Personnel, Public Grievances and Pensions, Parliamentary affairs presenting the merit certificate to Dr. Francis.

12.6 Promotion of Hindi

During the year 2010, various efforts were made to promote the use of Hindi in the institute. The Hindi official language implementation committee was reconstituted with Sri. K. K. V. Chary, Senior Administrative Officer, INCOIS as the Chairman. Regular meetings of the official language implementation committee were held to monitor the progress.



Hindi Pakhwara celebrations organized at INCOIS during September 2010.

Hindi Pakhwara celebrations were organized at INCOIS during September 2010. A seminar was held on 21 September 2010. Dr. D. D. Ojah, Scientist, Indian Society of Health, Environment, Education and Research, Jodhpur delivered a lecture on Water and Our life in Hindi. Competitions in essay writing and scientific presentation in Hindi were also held among INCOIS staff as part of Hindi Pakhwara celebrations. The prize winners delivered lectures in Hindi on their topics of research.

12.7 Vigilance activities

Dr. Ravichandran, Scientist 'F' and Head, MOG continued to function as the vigilance officer at INCOIS. The vigilance awareness week was observed from 3-7 November 2010. The pledge related to the vigilance awareness was taken by the officers and staff of INCOIS on 3 November 2010 at 11.00 A.M. During the period April - 2010 to March - 2011, no complaints related to vigilance were received.

12.8 Reservation Policy

Government of India's reservation policy for the recruitment of posts were followed at INCOIS.

Groups	Number of Employees				Number of appointments made during the calendar year 2010									
					By Direct Recruitment				By Promotion			By Other Methods		
	Total	SC	ST	OBC	Total	SC	ST	OBC	Total	SC	ST	Total	SC	ST
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group A	27	02	NIL	04	07	01	NIL	02	00	NIL	NIL	NIL	NIL	NIL
Group B	26	03	01	08	13	02	01	05	NIL	NIL	NIL	NIL	NIL	NIL
Group C	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Group D (Excluding Safai Karamchari)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Group D (Safai Karamchari)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
TOTAL	53	05	01	12	20	03	01	07	NIL	NIL	NIL	NIL	NIL	NIL

Representation Details of the staff belonging to reserved category

12.9 Right to Information Act

Right to Information Act, 2005 is being executed at INCOIS. Dr. S.S.C. Shenoi, Director, INCOIS and Sri. E. Pattabhi Rama Rao, Scientist 'D' and Head, DMG functioned as the public information officer and assistant public information officer respectively. Information about the activities of INCOIS and the staff were published on the website in the prescribed format under Right to Information Act 2005. Annual return form for the year 2010 was prepared as per the guidelines of the central information commission and the same was also published on INCOIS website. During the period April - 2010 to March - 2011, six requests under the right to information act were received and the information requested was provided.

12.10 Results Frame Work Document

As per government of India guidelines of "Performance Monitoring and Evaluation System (PMES)" vide PMO I.D. No 1331721/PMO/2009-Pol for government departments, an RFD document for INCOIS has been prepared is published on INCOIS website.

12.11 Deputations Abroad

1. S. S. C. Shenoi

To attend the 7th session of the Inter-Governmental Coordination Group for Indian Ocean Tsunami Warning and Mitigation System held during April 14-16, 2010 in Indonesia.

To attend 43rd session of the Executive council of the intergovernmental Oceanographic Commission (IOC) being held at UNESCO, Head quarters during Jun 08-16, 2010 in Paris France.

To attend 7th Session of Indian Ocean Global Ocean observing System July 09-16, 2010 in Perth, Australia.

To present India's bid proposal for organizing PORSEC-2012 in India during October 19-22, 2010 at National Taiwan Ocean University, Taiwan.

To visit facilities at Indian Research base "Maitri", Summer camp facilities and to inspect the alternate site for Maitri Station during December 19-21, 2010 in Antarctica.

To deliver a talk in International Symposium in com-memoration of the 50th anniversary of IOC/UNESCO during December 02-03, 2010 at University of Japan, Tokyo.

2. M. Ravichandran

To participate in the first IOC/WMO data buoy cooperation panel - In region western Indian Ocean capacity building workshop held at Weather Service during April 19-23, 2010 in Cape Town, South Africa.

To attend 7th Session of Indian Ocean- Global Ocean observing System during July 09-16, 2010 in Perth, Australia.

To attend the Joint Committee Meeting under the MOU signed between MoES and NOAA, USA during October 06-08, 2010 in Washington DC, USA.

To participate in "12th Argo Steering Team (AST-12)" meeting during March 14-17, 2011 at Buenos Aires, Argentina.

3. T. Srinivasa Kumar

To attend the 7th session of the Inter-Governmental Coordination Group for Indian Ocean Tsunami Warning and Mitigation System during April 14-16, 2010 at Banda Aceh, Indonesia.

To attend Working Group on Tsunamis and other Hazards related to sea level warning and mitigation systems May 05-06, 2010 in Portugal.

To attend IOGOOS workshop and 7th Annual meeting for capacity development in Ocean forecasting Demonstration Project for IOGOOS & SEAGOOS during July 09-16, 2010 at Perth, Australia.

To co chair ISPRS TC VIII/WG 1 during August 09-12, 2010 in Japan.

To participate in "Evaluation of the German Contribution to the Indonesian Tsunami Early Warning System" during September 28-30, 2010 at Jakarta & Bali, Indonesia.

To attend IOC's Inter-ICG Task Teams Meeting during November 29-December -01 2010 in USA.

To participate in the 8th IOGOOS annual meeting during February 22-24, 2011 at Iran.

To participate in the Working Group on Tsunamis during March 21-22, 2011 at Paris, France.

4. E. Pattabhi Rama Rao

To present India's bid proposal for organising PORSEC-2012 in India during October 19-22 at National Taiwan Ocean University, Taiwan.

To co-chair at the ISPRS Technical Commission IV/WG 1 (WG IV/1) Symposium during November 14-24, 2010 at Orlando, USA.

To participate in the IOC session during March 21-26, 2011 at Liege, Belgium.

5. T. V. S. Udaya Bhaskar

Training on Delayed Mode quality control software developed by CSIRO and subsequent transfer to the same to INCOIS during April 19-30, 2010 at Hobart, Australia.

To participate in the 11th meeting of Argo Data Management Team (ADMT-11) during October 18-22, 2010 at Hamburg, Germany.

6. M. Nagaraja Kumar

LOGOOS workshop and 7th Annual meeting for capacity development in Ocean forecasting Demonstration Project for LOGOOS & SEAGOOS during July 09-16, 2010 at Perth, Australia.

To participate in the 8th LOGOOS annual meeting during February 22-24, 2011 in Iran.

7. Ch Patanjali Kumar

To attend 3rd meeting of STB user conference and INCOIS STB system (2&3) acceptance tests and operations at SAIC campus during July 06-08, 2010 in USA.

8. N. Suresh Kumar

To attend training on RUDICS Iridium server and battery replacement for Argo floats at School of Oceanography, University of Washington and NOAA/PMEL during July 26-31, 2010 in USA.

9. P. A. Francis

To participate in the GODAE Ocean View Steering Team (GOVST) meeting and the JCOMM Expert Team Meeting on the Operational Ocean Forecast Systems (JCOMM/ET-OOFS) during October 04-09, 2010 at Tokyo, Japan.

10. T.M. Balakrishnan Nair

To attend the Joint Committee Meeting under the MOU signed between MoES and NOAA, USA, during October 06-08, 2010 at Washington DC, USA.

To attend Fifth Global Conference on oceans, coasts and islands: Ensuring Survival, preserving life, improving Governance during 02-05 May, 2010 at Paris, France

11. M. Vijayasunanda

For attending training program on advanced techniques for tsunami early warning system using GPS and Accelerometer data in collaboration with German Research Centre for Geo sciences (GFZ) during October 10 - December 10, 2010 at Potsdam, Germany.

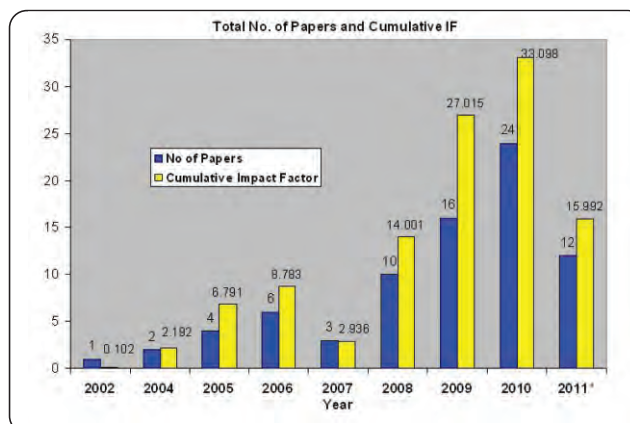
12. Aneesh A. Lotliker

To pursue training on “Modelling of Primary Productivity & Inherent Optical Properties” under POGO-SCOR Visiting Fellowships for 2010 during 05-March-2011 - 05-June-2011 at Plymouth Marine Laboratory, UK.

12.12 Publications

Twenty seven research papers were published in peer reviewed national and inter national journals during 2010-2011 high for the current financial year (2010-2011). The total impact factor of 27 papers is 33.9.

The growth in the publication of research papers since 2002.



List of Publications:

1. Annapurnaiah, K., Udaya Bhaskar, T.V.S., Balakrishnan Nair, T.M, Das, S., 2011, Validation of Mixed Layer Depth Derived using Satellite Data and Wave Model with In-Situ Observations, International Journal of Oceans and Oceanography, 5(1), pp. 23-34.
2. Deshpande, C.G., Pant, V., Kamra, A.K., 2010, Changes in concentration and size distribution of aerosols during fog over the south Indian Ocean, Journal of Earth System Science, 119 (4), pp. 479-487.
3. Francis, P.A., Gadgil, S., 2010, Towards understanding the unusual Indian monsoon in 2009, Journal of Earth System Science, 119 (4), pp. 397-415.

4. Gandhi, N., Kumar, S., Prakash, S., Ramesh, R., Sheshshayee, M.S., 2011, Measurement of marine productivity using ^{15}N and ^{13}C tracers: Some methodological aspects, *Journal of Earth System Science*, 120(1), pp. 99-111.
5. Gandhi, N., Prakash, S., Ramesh, R., Kumar, S., 2010, Nitrogen uptake rates and new production in the northern Indian Ocean, *Indian Journal of Marine Science*, 39(3), pp. 362-368.
6. Gandhi, N., Ramesh, R., Prakash, S., Kumar, S., 2011, Nitrogen sources for new production in the NE Arabian Sea, *Journal of Sea Research*, 65(2), pp. 265-274.
7. Geetha, G., Udaya Bhaskar, T.V.S., Rama Rao, E.P., 2011, Argo Data and Products of Indian Ocean for Low Bandwidth Users, *International Journal of Oceans and Oceanography*, 5(1), pp. 1-8.
8. Girish Kumar, M.S., Ravichandran, M., McPhaden, M.J., Rao, R.R., 2011, Intraseasonal variability in barrier layer thickness in the south central Bay of Bengal, *Journal of Geophysical Research*, 116, C03009, pp.1-9.
9. Gopalakrishna, V.V., Durand, F., Nisha, K., Lengaigne, M., Boyer, T.P., Costa, J., Rao, R.R., Ravichandran, M., Amrithash, S., John, L., Girish, K., Ravichandran, C., Suneel, V., 2010, Observed intraseasonal to interannual variability of the upper ocean thermal structure in the southeastern Arabian Sea during 2002-2008, *Deep-Sea Research-I*, 57(6), pp.739-754.
10. Kumar, B.P., Barman, R., Dube, S.K., Pandey, P.C., Ravichandran, M., Nayak, S., 2010, Development of a New Comprehensive Ocean Atlas for Indian Ocean utilizing ARGO Data, *International Journal of Climatology*, 32 (2), pp. 185-196.
11. Kumar, T.S., Mahendra, R.S., Nayak, S., Radhakrishnan, K., Sahu, K.C., 2010, Coastal Vulnerability Assessment for Orissa State, East Coast of India, *Journal of Coastal Research*, 26(3) pp. 523-534.
12. Mahendra R.S., Mohanty, P.C., Kumar, T.S., Shenoi, S.S.C., Nayak, S., 2010, Coastal Multi-Hazard Vulnerability Mapping: A Case Study Along The Coast of Nellore District, East Coast of India, *Italian Journal of Remote Sensing*, 42(3), pp.67-76.
13. Mahendra, R.S., Mohanty, P.C., Bisoyi, H., Kumar, T.S., Nayak, S., 2011, Assessment and Management of Coastal Multi-hazard Vulnerability along the Cuddalore-Villupuram East Coast of India using Geospatial Techniques, *Ocean & Coastal Management*, 54, pp. 302-311.
14. Menon H.B., Nutan, S., Lotliker, A., Krishnamoorthy, K., Vethamony, P., 2011, Aerosol optical thickness and spatial variability along coastal and offshore waters of the eastern Arabian Sea, *ICES Journal of Marine Science*, 68(4), pp.745-750.
15. Pant, V., Singh, D., Kamra, A.K., 2010, Concentrations and size distributions of aerosol particles at Maitri during the passage of cyclonic storms revolving around the continent of Antarctica, *Journal of Geophysical Research*, 115, D17202, pp.1-15.

16. Parampil, S. R., Gera, A., Ravichandran, M., Sengupta, D., 2010, Intraseasonal response of mixed layer temperature and salinity in the Bay of Bengal to heat and freshwater flux, *Journal of Geophysical Research*, 115, C05002, pp. 1-17.
17. Prakash, S., Ramesh, R., Sheshshayee, M.S., Rahul, M., Sudhakar, M., 2010, Effect of high level iron enrichment on potential nitrogen uptake by marine plankton in the Southern Ocean, *Current Science*, 99 (10), pp.1400-1404.
18. Pushpadas, D., Vethamony, P., Sudheesh, K., George, S., Babu, M.T., Balakrishnan Nair, T.M., 2010, Simulation of coastal winds along the central west coast of India using the MM5 mesoscale model, *Meteorology and Atmospheric Physics*, 109(3-4), pp.91-106.
19. Rahul, P.R.C., Salvekar, P.S., Sahu, B.K., Nayak, S., Kumar, T.S., 2010, Role of a Cyclonic Eddy in the 7000-Year-Old Mentawai Coral Reef Death During the 1997 Indian Ocean Dipole Event, *Geoscience and Remote Sensing Letters*, 7(2) pp. 296-300.
20. Sanil K., Philip, V., Sajiv, C., Balakrishnan Nair, T.M., 2010, Waves in shallow water off west coast of India during the onset of summer monsoon, *Annales Geophysicae*, 28, pp. 817-824.
21. Shenoi, S.S.C., 2010, Intra-seasonal variability of the coastal currents around India: A review of the evidences from new observations, *International journal of Geo Marine Science*, 39(4), pp.489-496.
22. Suresh, R.R.V., Annapurnaiah, K., Reddy, K.G., Lakshmi, T.N., Balakrishnan Nair, T.M., 2010, Wind sea and Swell Characteristics off East coast of India During Southwest Monsoon, *International Journal of Oceans and Oceanography*, 4(1), pp.35-44.
23. Udaya Bhaskar, T.V.S., Swain, D., Ravichandran, M., 2010, Sonic Layer Depth Variability in the Arabian Sea, *International Journal of Oceans and Oceanography*, 4(1), pp.17-28.
24. Vialard, J., Terray, P., Duvel, J.P., Nanjundiah, R.S., Shenoi, S.S.C., Shankar, D., 2011, Factors controlling January-April rainfall over southern India and Sri Lanka, *Climate Dynamics*, pp. 1-15.
25. Warakish, G.S.D, Natesan, U., Nayak, S., Chauhan, P., Nagur, C.R.C., 2010, Analysis of IRS-P4 OCM data for estimating the suspended sediment concentrations along the Mangalore Coast, India, *International Journal of Imaging*, 3(10), pp. 23-39.
26. Yadav, R.B.S., Papadimitriou, E.E., Karakostas, V.G., Shanker, D., Rastogi, B.K., Chopra, S., Singh, A.P., Kumar, S., 2011, The 2007 Talala, Saurashtra, western India earthquake sequence: Tectonic implications and seismicity triggering, *Journal of Asian Earth Sciences*, 40(1), pp. 303-314.
27. Yadav, R.B.S., Tripathi, J.N., Shanker, D., Rastogi, B.K., Das, M.C., Kumar V., 2011, Probabilities for the occurrences of medium to large earthquakes in Northeast India and adjoining region, *Natural Hazards*, 56(1), pp. 145-167.

12.13 Consultancy Projects

During the year, INCOIS tookup/completed the following projects for industrial/commercial users.

No.	Title of the Project	Client
1.	The Short term changes in the landforms around the Krishnapatnam Port Area in Nellore District of Andhra Pradesh (Phase-II) (On going since May 2009).	Krishnapatnam Port Ltd. (Map World Tech.)
2.	A Satellite Based Study for Landuse/Landcover Mapping, Spatio-Temporal Changes in Vegetation around TATA Chemicals Limited, Mithapur Environs, Gujarat (Ongoing since April 2009).	TATA Chemicals Ltd. Gujarat
3.	Assessment of Shoreline Change using Remote Sensing and GIS Techniques around Porto Novo (Apr-June 2010).	IL&FS Maritime Infrastructure Company Limited
4.	Significant wave height estimates to prepare inland vessel limits(IVL) (continuing from October 2009).	Andaman Port Authority
5.	The wave characteristics off Machilipatanam during cyclone Jal (5-8 Nov-2010).	Bharat salt Refineries

Table 5: Consultancy projects executed during 2010.

13. List of Acronyms

ADCP	: Acoustic Doppler Current Profiler
ADPC	: Automatic Data Processing Chain
AOGS	: Asia Oceania Geosciences Society
AVHRR	: Advanced Very High Resolution Radiometer
AWS	: Automated Weather Stations
BI	: Bloom Indices
BLT	: Barrier Layer Thickness
BPR	: Bottom Pressure Recorder
CAOS	: Centre for Atmospheric and Oceanic Sciences
CBAS	: Coral Bleaching Alert System
CHLOROGIN	: Chlorophyll Global Integration Network
CMFRI	: Central Marine Fisheries Research Institute
CMLRE	: Central Marine Living Resources and Ecology
CORE	: Co-ordinated Ocean Ice Reference Experiments
CSBoB	: Centre for Studies on Bay of Bengal
CSIRO	: Commonwealth Scientific and Industrial Research Organization
CTD	: Conductivity, Temperature, Depth Sensors
CUPOM	: Colorado University Princeton Ocean Model
CVI	: Coastal Vulnerability Indices
DHW	: Degree of Heating Weeks
DMG	: Data Management Group
DSS	: Decision Support System
EDB	: Electronic Display Boards
ENVISAT	: Environmental Satellite
ESA	: European Space Agency
ET-OOFS	: Expert Team on Operational Oceanographic Forecasting Systems
FSI	: Fishery Survey of India
GC	: Governing Council
GDP	: Gross Domestic Production

GHRST	:	Global High Resolution Sea Surface Temperature
GIS	:	Geographic Information System
GODAS	:	Global Ocean Data Assimilation System
GOOS	:	Global Ocean Observation System
GOVST	:	GODAE Ocean View Steering Team
GPRS	:	General Packet Radio Service
GTS	:	Global Telecommunication System
HAB	:	Harmful Algal Bloom
HPC	:	High-performance Computing
HS	:	Hot Spot
HYCOM	:	HYbrid Coordinate Ocean Model
ICCSIR	:	Indian Centre for Climate and Societal Impacts Research
ICG	:	International Crisis Group
IL	:	Isothermal Layer
ILD	:	Isothermal Layer Depth
INCOIS	:	Indian National Centre for Ocean Information Services
INDOFOS	:	Indian Ocean Forecast System
INDOMOD	:	Indian Ocean Modelling and Dynamics
INSAT	:	Indian National Satellite
IOC	:	Intergovernmental Oceanographic Commission
LOGOOS	:	Indian Ocean Global Ocean Observation System
IOTWS	:	Indian Ocean Tsunami Warning System
ISRO	:	Indian Space Research Organization
ISRS	:	Indian Society of Remote Sensing
ITEWC	:	Indian Tsunami Early Warning Centre
IVL	:	Inland Vessel's Limit
JCOMM	:	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
LAS	:	Live Access Server
LFA	:	Logistical Framework Approach
LISS	:	Linear Imaging Self-Scanning System

MCSST	: Multi-Channel Sea Surface Temperature
MERIS	: Medium Resolution Imaging Spectrometer
MODIS	: Moderate Resolution Imaging Spectroradiometer
MoES	: Ministry of Earth Sciences
MOM	: Modular Ocean model
MoU	: Memorandum of Understanding
MSS	: Mobile Satellite System
NCEP	: National Centers for Environmental Prediction
NGO	: Non-governmental Organization
NIOT	: National Institute of Ocean Technology
NOAA	: National Oceanic and Atmospheric Administration
NODPAC	: Naval Operational Data Processing and Analysis Centre
NOGAPS	: Navy's Operational Global Atmospheric Prediction System
NTWC	: National Tsunami Warning Centre
OCM	: Ocean Colour Monitor
ODIS	: Ocean Data and Information System
OGCM	: Ocean General Circulation Model
ONGC	: Oil and Natural Gas Corporation
OSF	: Ocean State Forecast
OSTIA	: Operational Sea Surface Temperature and Sea Ice Analysis
PFZ	: Potential Fishing Zone
PIRATA	: Prediction and Research Moored Array in the Atlantic
PMEL	: Pacific Marine Environmental Laboratory
POGO	: Partnership for Observation of the Global Oceans
PORSEC	: Pan Ocean Remote Sensing Conference
PRL	: Physical Research Laboratory
RAMA	: Research Moored Array for African–Asian–Australian Monsoon Analysis and Prediction
RCA	: Rolling Chlorophyll-a Anomaly
RIMES	: Regional Integrated Multi-hazard Early Warning System
RMSE	: Root-Mean-Square Error

RTSP	:	Regional Tsunami advisory Service Provider
RTWP	:	Regional Tsunami Watch Provider
SAARC	:	South Asian Association For Regional Cooperation
SAIC	:	Science Applications International Corporation
SATCORE	:	Satellite Coastal and Oceanographic Research
SCOR	:	Scientific Committee on Oceanic Research
SDMC	:	SAARC Disaster Management Centre
SEA-GOOS	:	Southeast Asian GOOS
SeaWiFS	:	Sea-viewing Wide Field-of-view Sensor
SIBER	:	Sustained Indian Ocean Biogeochemistry and Ecosystem Research
SMS	:	Short Message Service
Sol	:	Survey of India
SSHA	:	Sea Surface Height Anomaly
SST	:	Sea Surface Temperature
TAO	:	Tropical Atmosphere Ocean
TRITON	:	Triangle Trans-Ocean Buoy Network
TSM	:	Total Suspended Matter
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
USA	:	United States of America
VSAT	:	Very Small Aperture Terminal
WMO	:	World Meteorological Organization
XBT	:	Expendable Bathythermograph
XCTD	:	Expendable CTD



