In situ Ocean Observation Networks in the Indian Ocean

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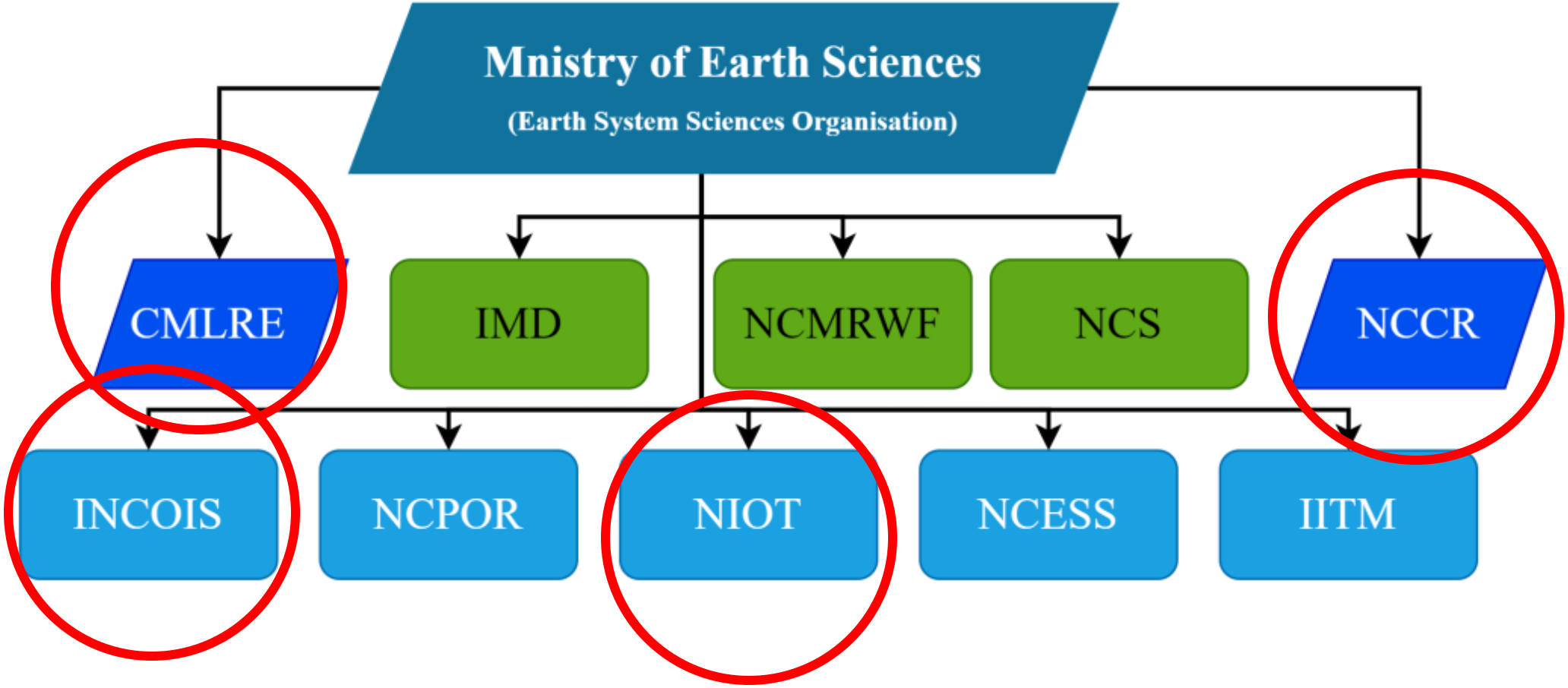
Data Buoy Cooperation Panel (DBCP) Capacity Building Workshop
Ocean Observations for Operational Services in the Indian Ocean Region

05 - 07 August 2025
Hyderabad, India

In situ Observation in Indian Ocean



CSIR-NIO

Academia

India's Ocean Observation Network (OON)

Objectives

- Establish **ocean observation network** to collect sustained long term marine meteorological and oceanographic data from open ocean and coastal waters of the tropical Indian Ocean to facilitate
  - Ocean Information and Advisory **Services**
  - **Data assimilation** in the ocean and atmospheric models
  - **Validation** of operational nowcast / forecast of ocean variables.
  - Understanding **oceanographic processes** and air-sea interactions
- Conduct **Field Campaigns** for Process Specific Studies to
  - Quantify **mixing processes**
  - Validate the performances of existing **parameterization schemes** used in the OGCM
  - **Fine-tune** the existing parameterization scheme or develop new schemes.
  - Fine-tune and refine the bulk flux algorithm
- **Capacity building**, education, and training and inter-institutional project.

INCOIS Observations

Open Ocean

- Argo Float Network (50 per year)
- Drifting Buoy Network (25 in last 3 years)
  - Wave and oil spill drifter
- XBT/XCTD Transects (3 shipping lines)
- Glider Transect (2 transects)
- Tsunami Buoy Network (4 locations)
- AWS Network on Research Vessels (34)
- Wave Height Meter (1)
- Equatorial Current Meter Moorings (3)
- Flux Mooring in the Bay of Bengal
- BGC Sensors on Arabian Sea OMNI Mooring
- RAMA Network (until 2017)
- Process Specific Observations: uCTD, VMPs, ASIMET, LADCP, ECFS, Radiometers

Coastal

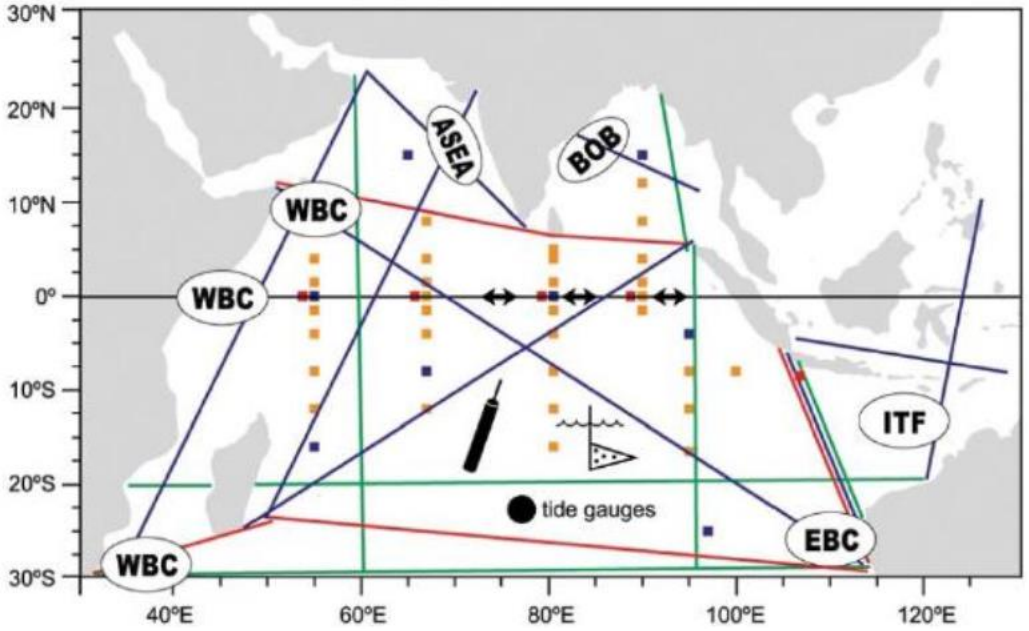
- Tide Gauge Network (36)
- GNSS and SMA Network (35)
- Wave Rider Buoy Network (16)
- Coastal ADCP Network (17)
- Coastal Water Quality Buoy Network (6)
- SATCORE Observations (11)

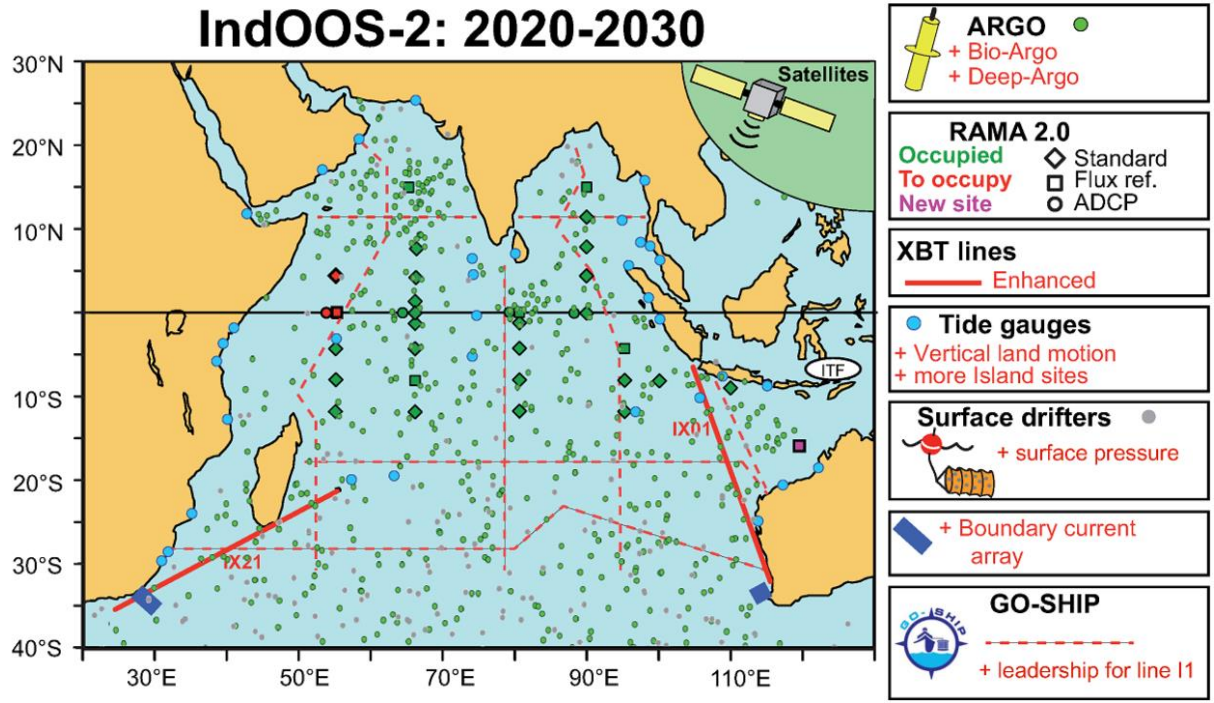
NIOT Observations

- OMNI Buoy & Tsunami Buoy Network (3)
- HF Radar (5) & RAMA Network (Since 2017)

Challenge 7 - Expand the Global Ocean Observing System

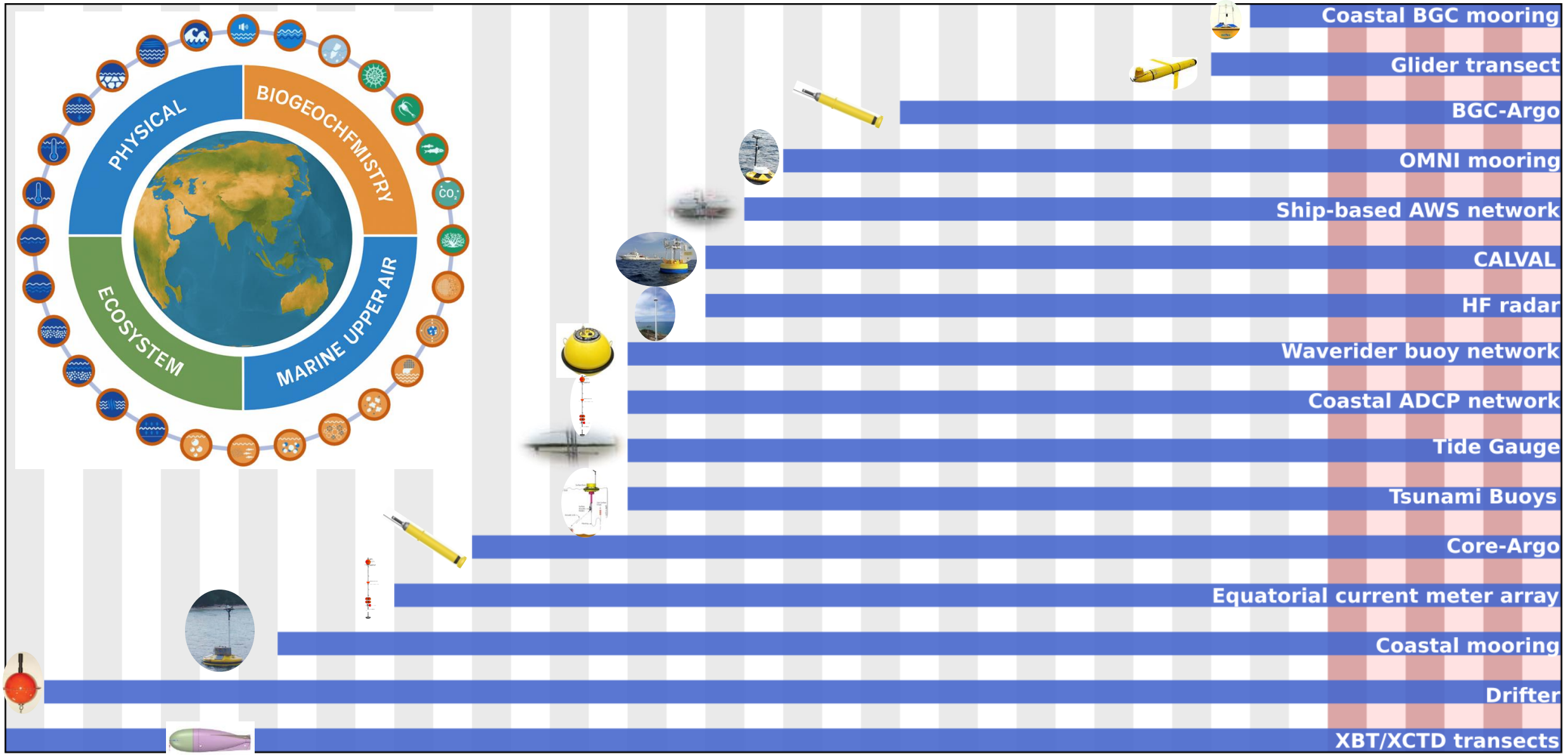
Ensure a sustainable ocean observing system across all ocean basins that delivers accessible, timely, and actionable data and information to all users





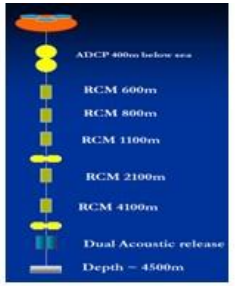
CLIVAR, in collaboration with IOGOOS and the Intergovernmental Oceanographic Commission, is working to design and implement an integrated observing system for the Indian Ocean

Evaluation of Ocean Observation Network

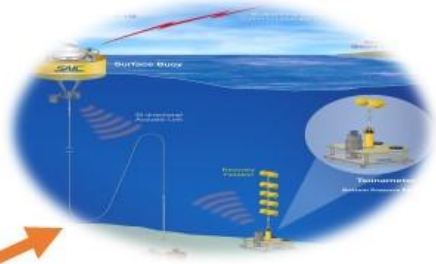


Sustained Observation in Indian Ocean - INCOIS

ADCP
16 Nos

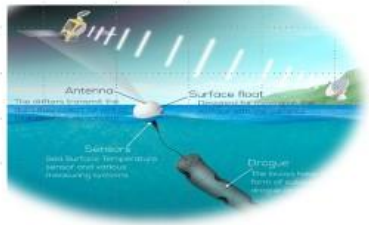


GNSS & SMA



Argo
40 Core + 10 BGC per year

BPR
07 Nos



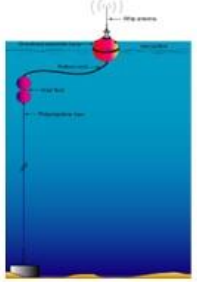
Drifter
30 Nos per year

Tide Gauge
36 Nos

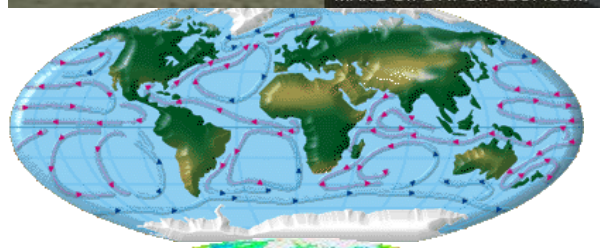
XBT
3 transects

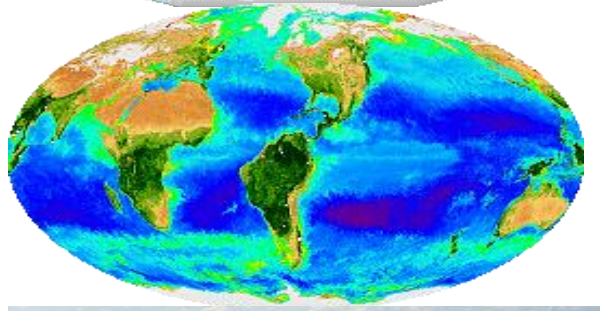
AWS
34 Nos

WRB
16 Nos



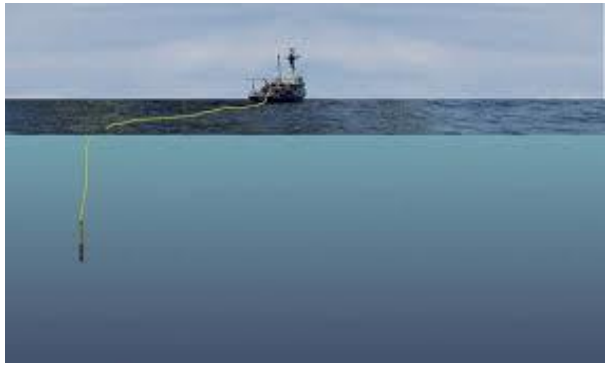
BGC
2 Nos





Instruments for Process Specific Observation

uCTD

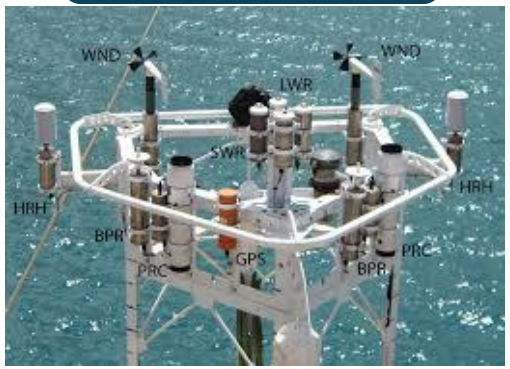


CTD

Radiometer

Glider

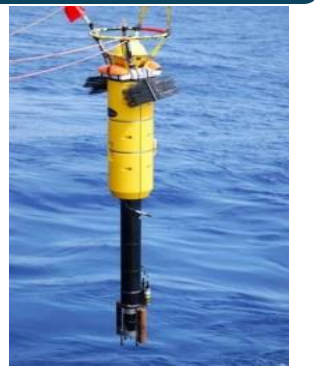
ASIMET



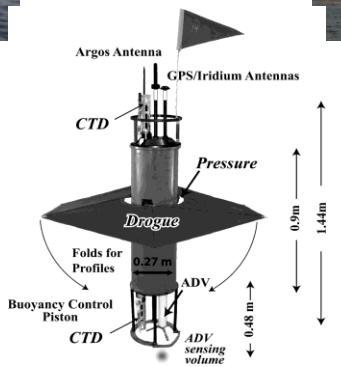
Flux mooring

ECFS

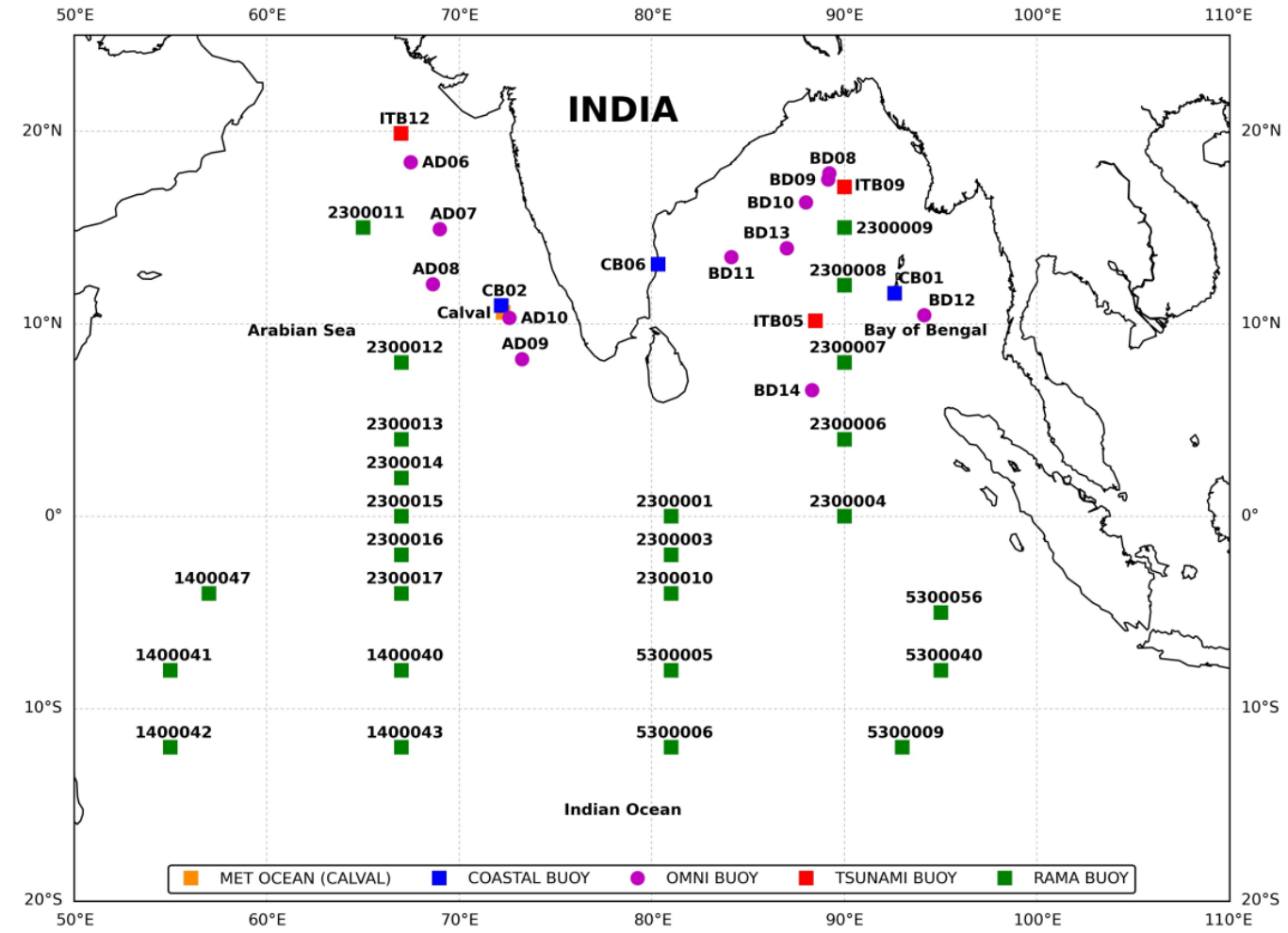
VMP

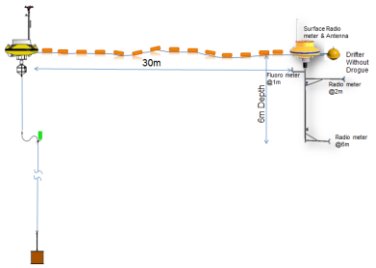


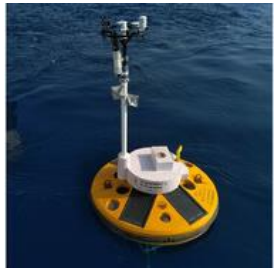
Lagarangian float

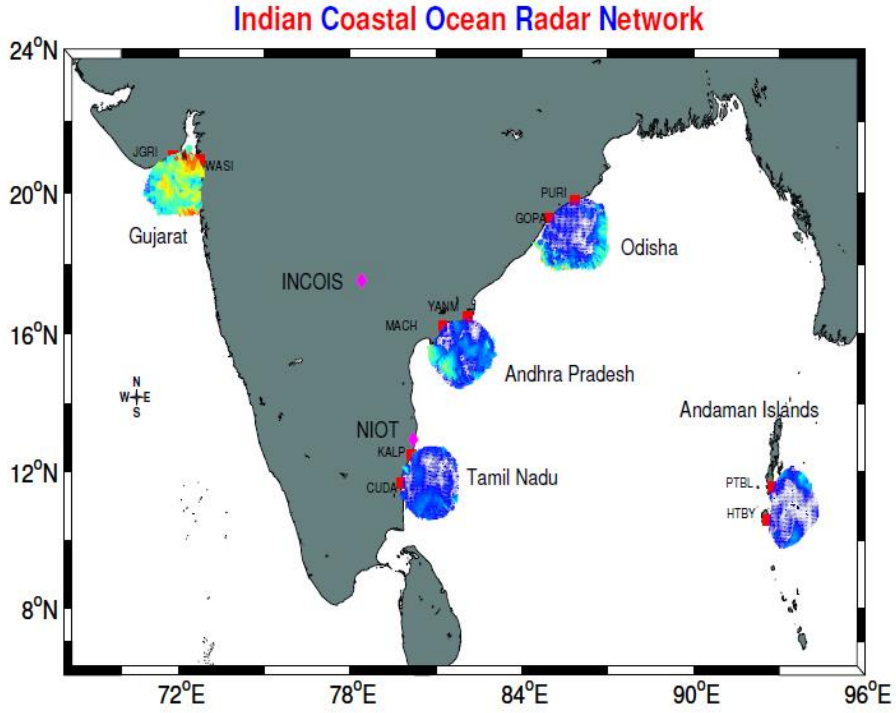


Sustained Observation in Indian Ocean - NIOT



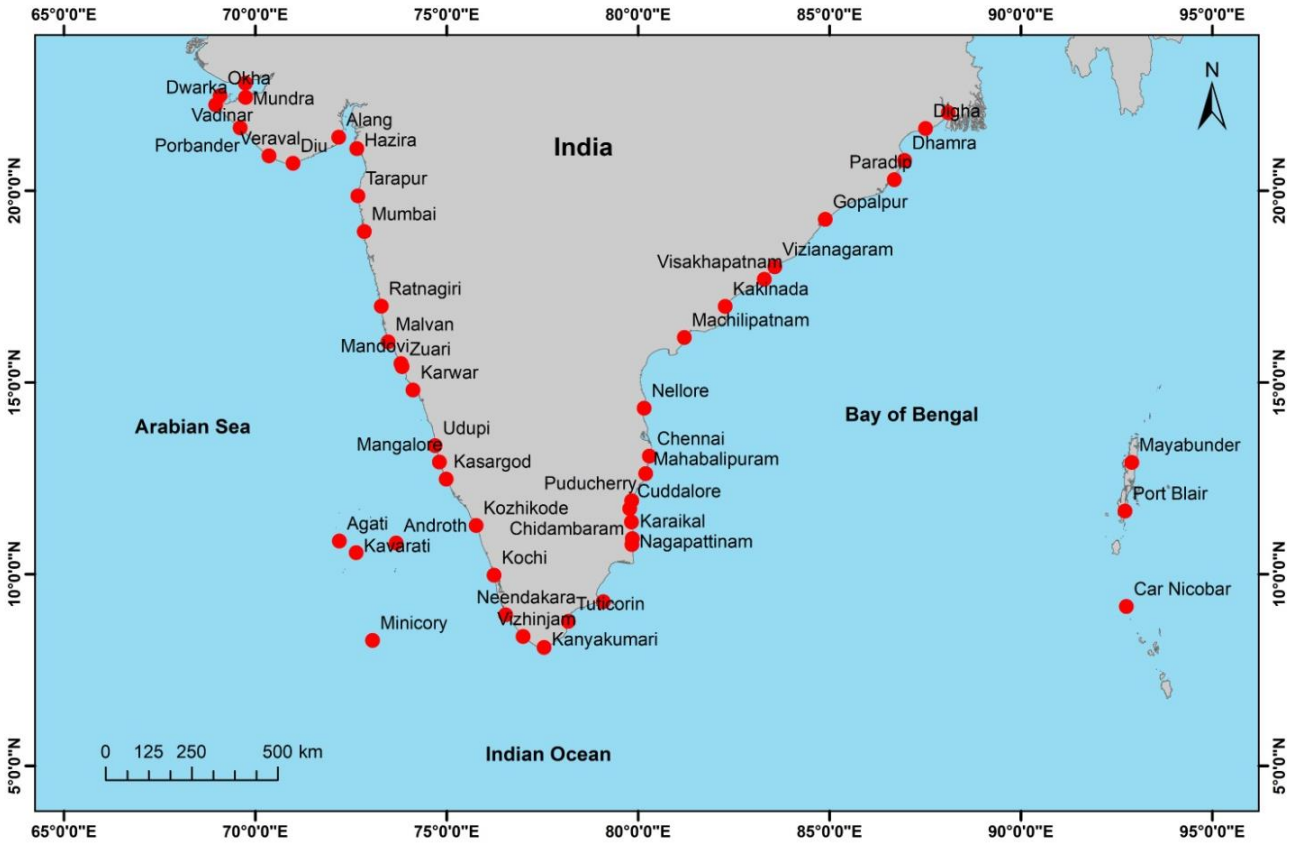






Sustained Observation in Indian Ocean - NCCR

SWQM Monitoring locations



Monitoring locations :50 (hotspots & relatively undisturbed)
Number of stations : 1, 2, 3, 5 Km
Periodicity : biannual (Pre- & post- monsoon)
GIA Institutes : ANCOST-NIOT

Methodology

Water
Temperature, Salinity, pH, DO, BOD, TSM, TA, DIC, Nutrients, Trace Metals, PHC, Chlorophyll pigments

Water (Biology)
Phytoplankton
Zooplankton
Microzooplankton

Microbial (water & sediment)
Total Viable Count
Escherichia coli
Faecal coliform
Streptococcus faecalis

Sediment
Organic carbon, Texture, Trace Metals, PHC
Benthos

Argo Float Network

Argo Programme is a component of GOOS

- INCOIS is leading the Indian Argo Programme
- Complement the other in-situ ocean observation in the Indian Ocean - IndOOS / IOGOOS
- Deploy 50 Floats per year (3:2 of TS and Bio Argo)
- INCOIS serves as the Regional Argo Centre (RAC) in the Indian Ocean and also serves as National Data Assembly Centre (DAC)

Parameters

- Vertical profile of Temp, Sal, Chl-a, DO, Backscatter and Nitrate up to 2000 m with 10 day typical mission

Applications

- Improve Ocean and Climate forecasting
- Understand ocean-atmosphere interactions
- Predict seasonal to decadal climate variability
- Wide range of applications for high-quality global ocean analyses
- Data Assimilation in OGCM

Data availability

- GTS and INCOIS website in near real time
- Real-time data for operational purpose and Delayed-mode data for research purpose
- Derived Data products are available online

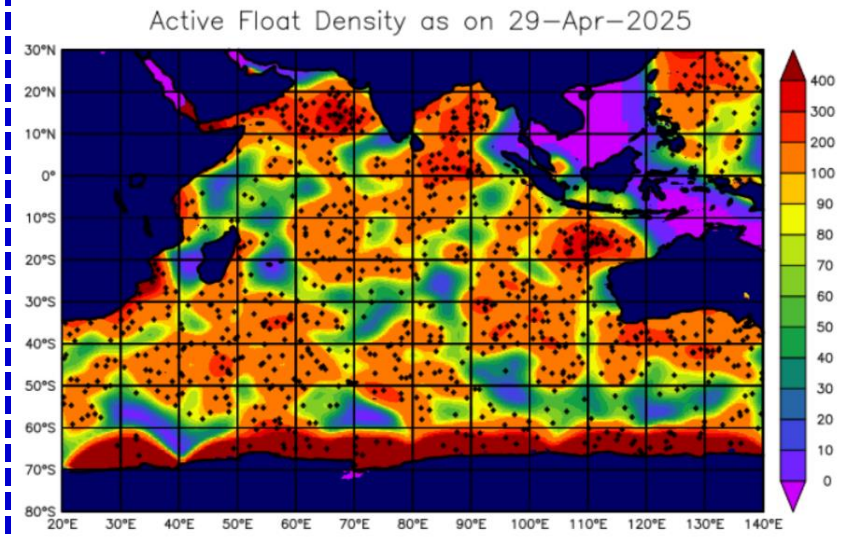
Current Status

- **Total Floats Deployed: 587 & Active Floats: 115**

Future Plan

- 50 floats/year (40 Core + 10 BGC)

Indian Ocean ARGO Floats Density Map



Drifting Buoy Network

Drifting Buoy Network is a Global array of ocean surface drifters

Parameters

- Near-surface water temperature and atmospheric pressure.

Applications

- Accurate and globally dense set of in-situ observations of mixed layer currents, sea surface temperature, atmospheric pressure, winds, waves, and salinity.
- Near-real time data (SST, sea level pressure and surface winds on GTS) for operational weather analysis and prediction
- Development of monthly mean mixed-layer velocities in the Indian Ocean on 1° x 1° resolution.
- 'Sea truths' for validation of remotely sensed ocean surface parameters.

Data availability

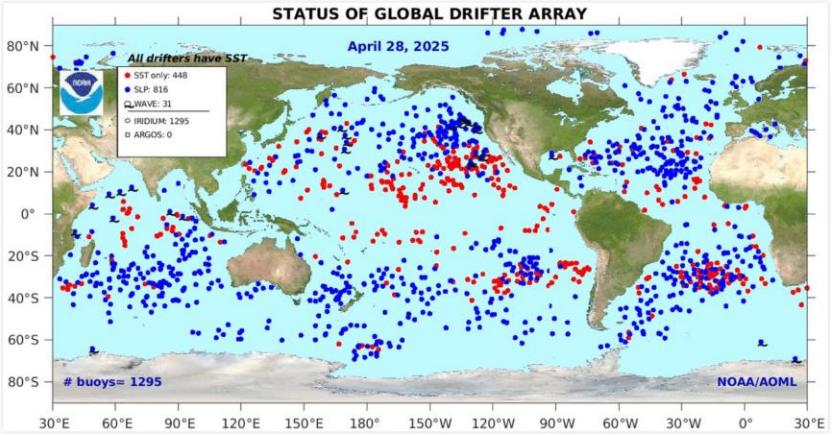
- GTS and INCOIS website in near real time.

Current status

- Since INCOIS took over the programe in 2027, 39 were deployed and three are active

Future Plans

- 30 Drifters/year (at least one float in 5x5 grid)



XBT / XCTD Transects

Programme is executed in collaboration with NIO

Parameters

- Vertical profile of temperature (XBT)
- Vertical profile of temperature and salinity (XCTD) up to 760m

Applications

- Long term monitoring of upper ocean thermal fields in the seas around India.
- To understand interannual variability of volume transport.
- To provide data in the Argo sparse region in the in the Indian EEZ.
- To provide data source for ocean re-analysis.

Data availability

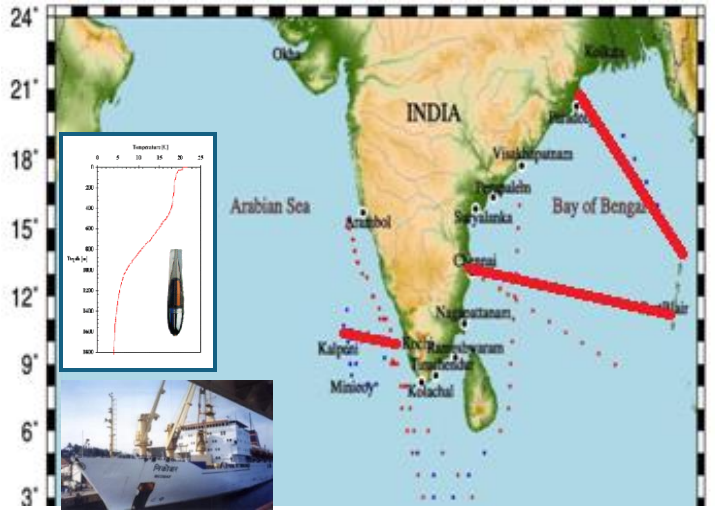
- Delayed-mode
- Real-time transmission of data using INSAT Communication is under testing phase

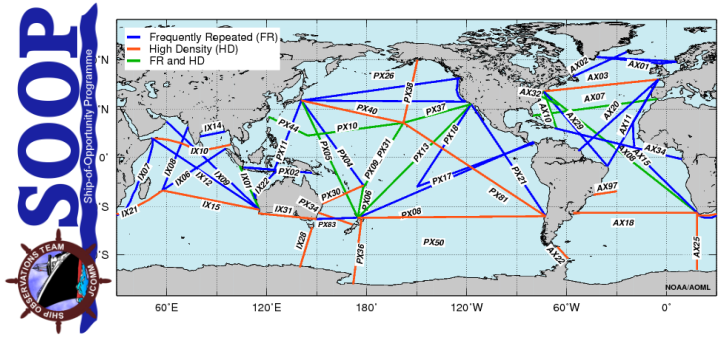
Current status

- 3 XBT/XCTD transects along Chennai-Port Blair, Port Blair-Kolkata and Kochi-Lakshadweep were maintained.

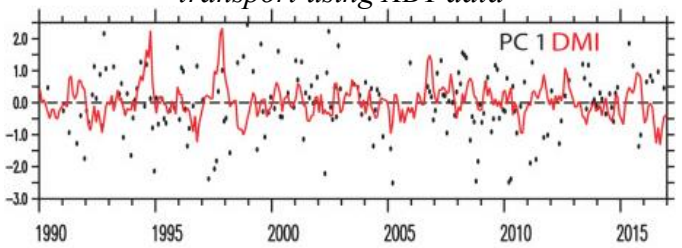
Future plan

- Maintain the existing three transects





Interannual variability of volume transport using XBT data



Coastal ADCP & Equatorial Current Meter Network

Network is maintained in collaboration with NIO

Parameters

- Vertical profile of current at different Depths

Applications

- Long-term variability of ocean currents in the coastal shelf, slope and equatorial Indian Ocean.
- Seasonal, intra-seasonal and inter-annual variability of ocean currents along the Indian Coast and equatorial Indian Ocean.
- Deep-sea circulation in the equatorial Indian Ocean
- Volume transport by coastal current between the Arabian Sea and Bay of Bengal.
- Heat, salt and volume transport along the equatorial region.
- Validation of ocean currents from OGCM.

Data availability

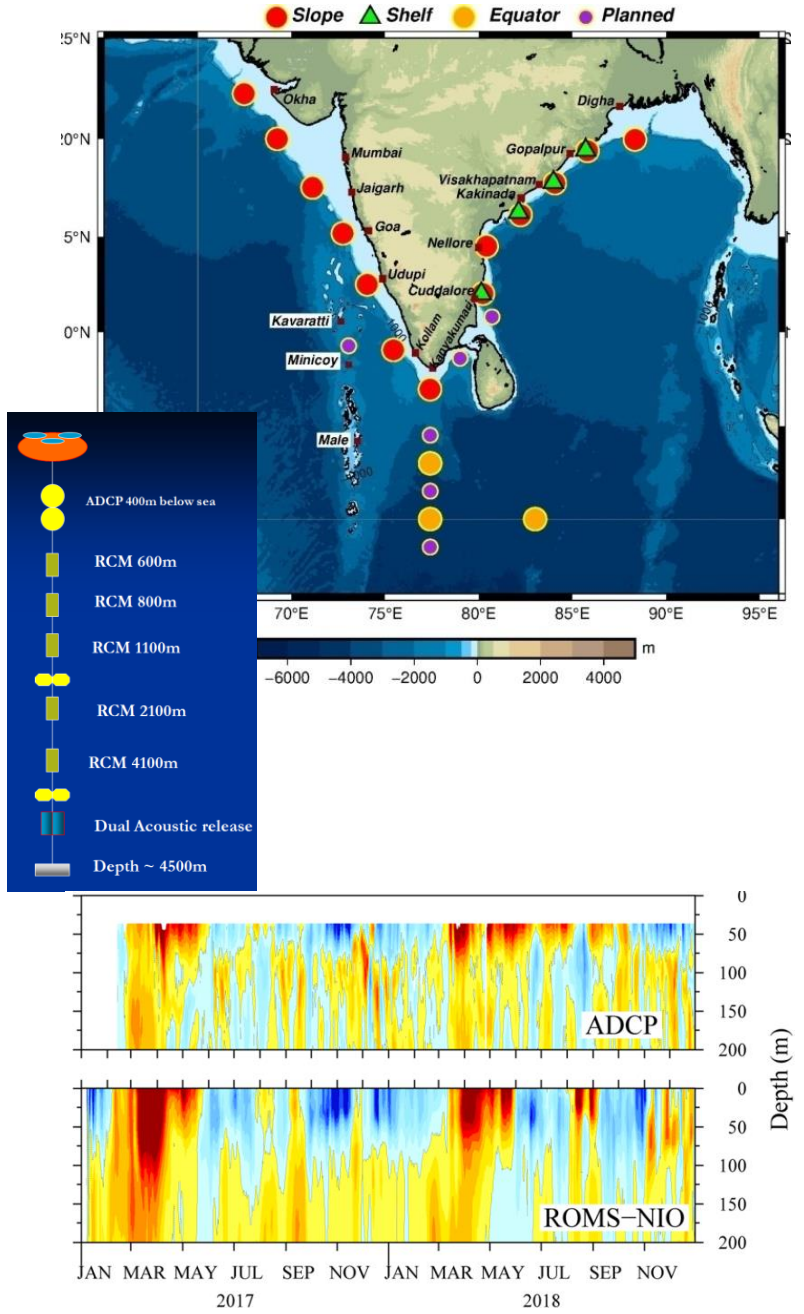
- Delayed-mode

Current status

- Coastal ADCP [West coast (7 slope) and East coast (6 slope and 4 shelf)]
- Equatorial current meter (three moorings)

Future plan

- Sustain the existing equatorial array of moorings.



Wave Rider Buoy Network

Parameters

- All wave parameters , surface currents and SST

Applications

- Real-time evaluation of operational wave forecast
- Validation of wave model output and Remote Sensing Data
- Understanding variation of wave characteristics in different time scales
  - Diurnal – Kondalkattu
  - Intra-seasonal – MISO
  - Inter-annual – ENSO and IOD

Data availability

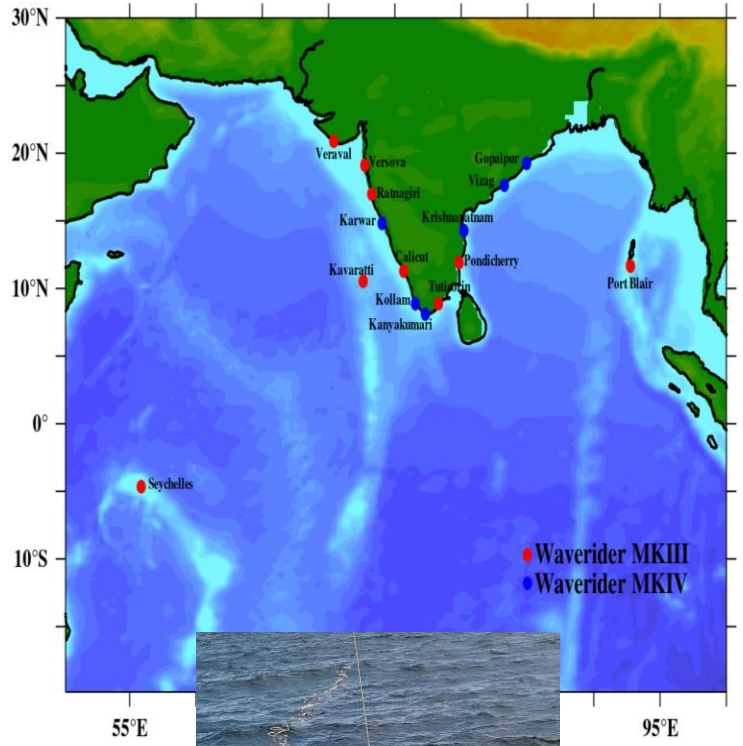
- Real-time via INSAT

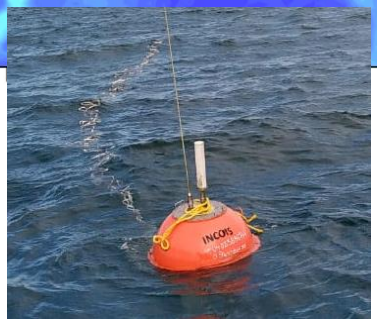
Current status

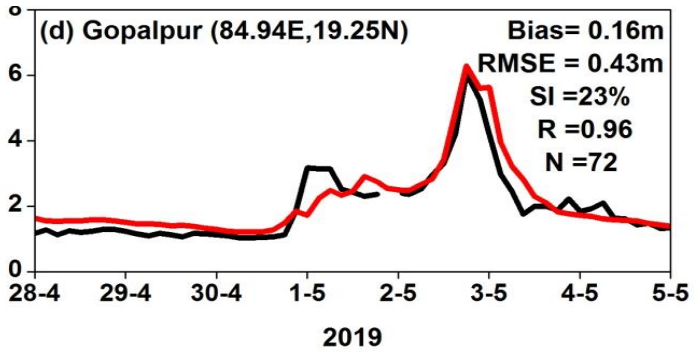
- Maintained 16 wave rider buoys (15 along Indian Coast and 1 at Seychelles)
- MKIII (9 Nos) & MKIV (6 Nos)

Future Plan

- Sustain 16 WRBS & Deploy one off Mauritius







Tide Gauge Network

Parameters

- Sea Level

Applications

- Monitoring and confirmation of the tsunami and its propagation
- Validate the tsunami, storm surge and other model results.
- Understand the processes which result in variations in the mean sea level.
- Climatic impact on sea level
- Navigation at Port & Horbours
- Other research applications: coastal trapped waves and sea level changes

Data availability

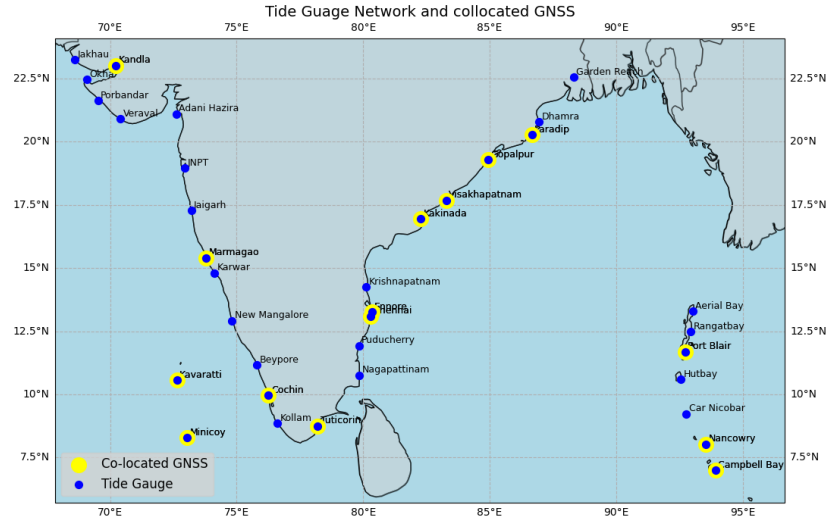
- GTS and INCOIS website in near real time for operational
- Delayed-mode data for research purpose.
- Eight Tide gauges data to IOC Sea level stations monitoring facility
- Communication through INSAT/GPRS

Current status

- 36 + 14 new tide gauge station along Indian coast line and Islands.

Future Plan

- Sustain 50 (36 existing and 14 New) Tide Guages
- Collocate GNSS with Tide Gauge



Tsunami Buoy Network

The network comprises of BPRs transmitting real time data through satellite communication

Parameter

- Sea Level

Applications

- Monitoring and confirmation of tsunami
- Validate the tsunami model results.
- The data is being sharing for research purpose as well.

Data availability

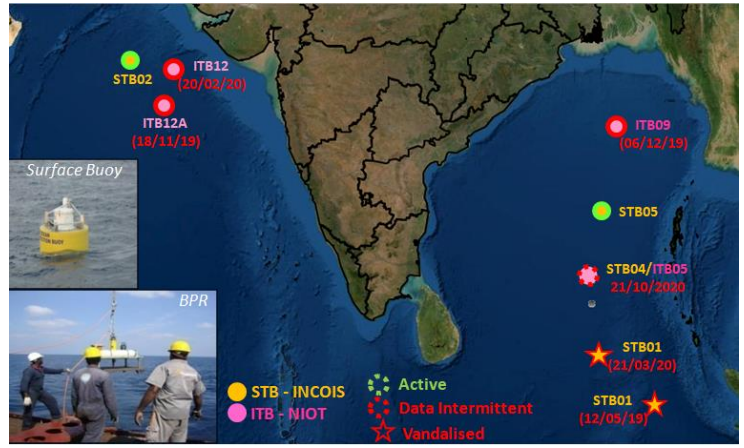
- Data is being received in real-time via acoustic & Satellite links
- GTS and INCOIS website in near real time.
- Real-time data for operational purpose
- Delayed-mode data for research purpose.
- INCOIS is sharing all Tsunami buoys data to NDBC NOAA

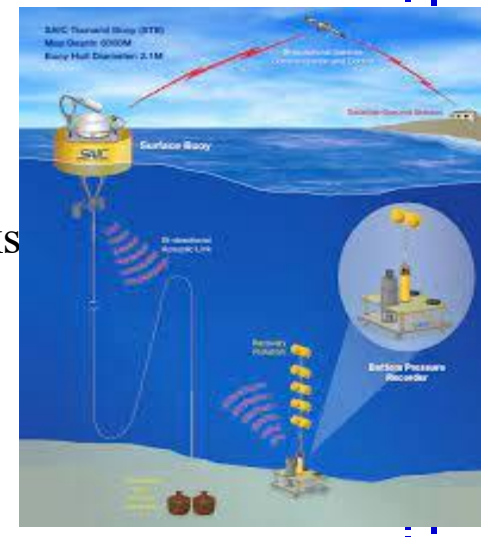
Current status

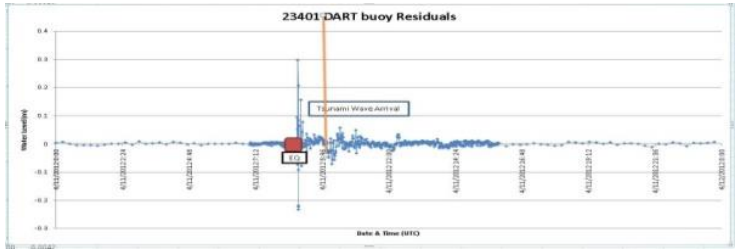
- 4 SAIC Tsunami Buoys (STBs) by INCOIS and 3 Indigenous Tsunami Buoys by NIOT.

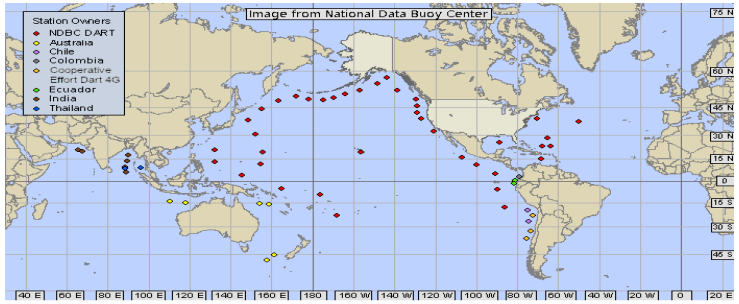
Future Plan

- The network will be maintained by NIOT with Indigenous setup









Coastal Water Quality Buoy Network

Parameters

- CTD, current, Chl-a, DO, scattering, turbidity, pCO2, pH, inorganic nutrients, CDOM, phycocyanin, phycoerythrin, hydrocarbon, dissolved methane

Applications

- Long-term changes in coastal water quality
- Understand coastal hypoxia, eutrophication, Ocean acidification etc
- Calibrate/validate satellite data and develop/improve semi-analytical algorithms.
- Validation / tuning of high-resolution coastal biogeochemical model
- Provide water quality services such as Algal bloom information, jelly fish aggregation, Trophic state index ec.

Data availability

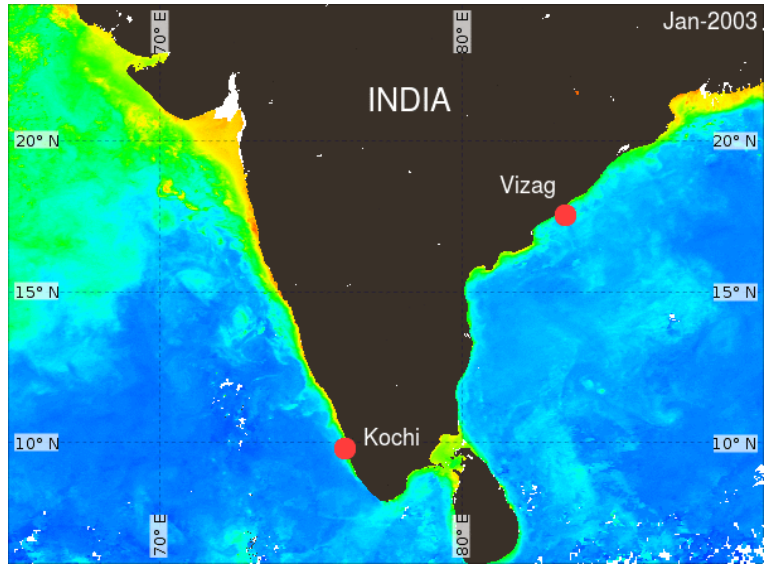
- Real-time

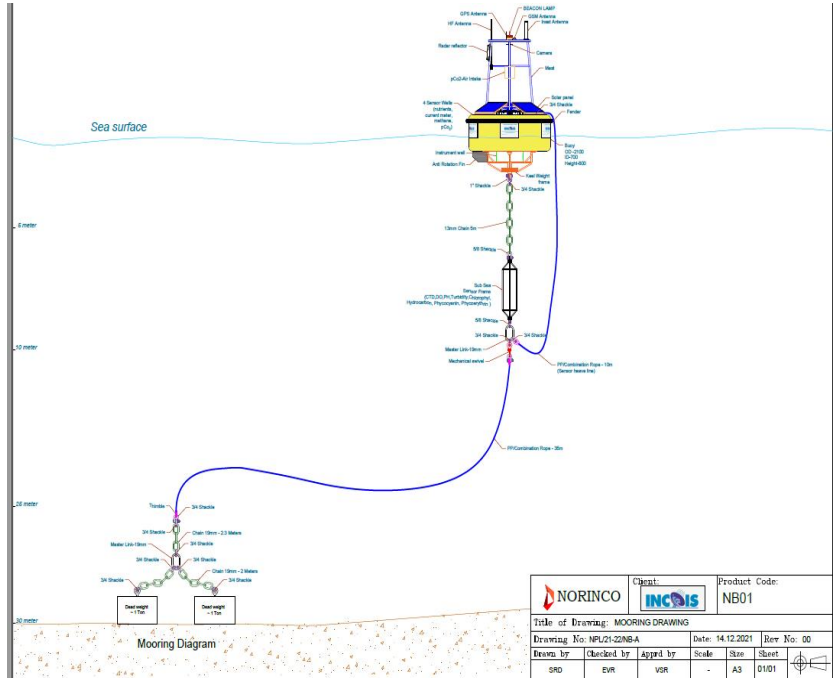
Current status

- Procurement of two observatories are in process
- Initiated water quality sampling at proposed location in collaboration with CSMCRI, NIO-Goa, NIO-Kochi, NIO-Vizag

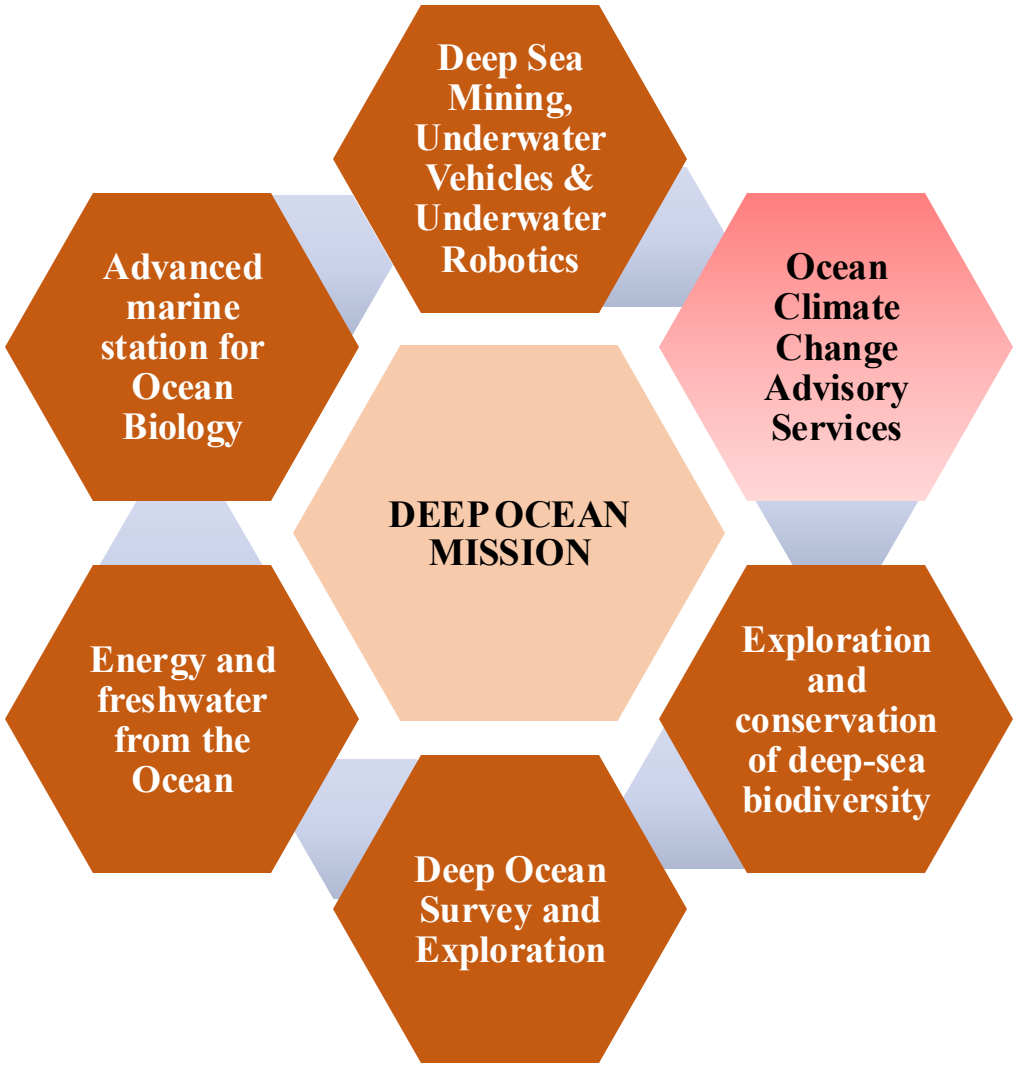
Future plan

- Sustain observatory off Kochi and Visakhapatnam





Deep Ocean Mission

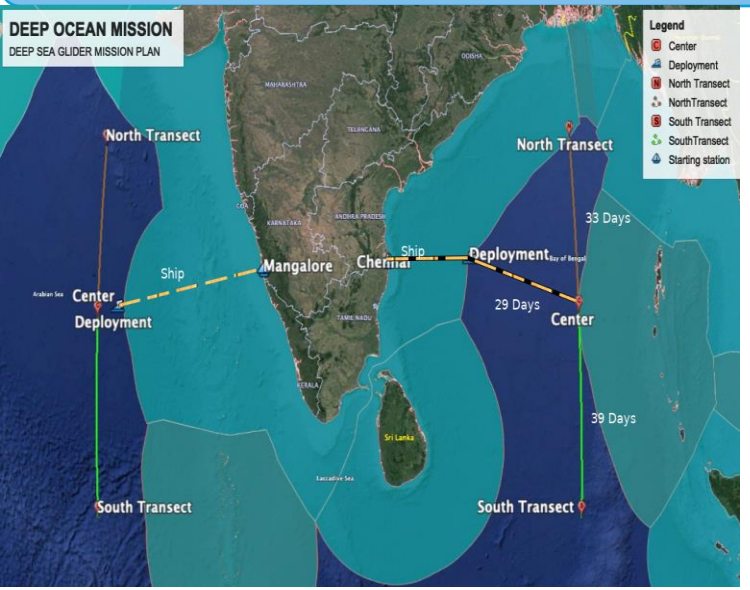


- Robust and accurate "regional" climate change assessment for the North Indian Ocean.
- Provide advisories on the future projections of important climate variables on decadal to longer time scales and associated impacts on the coastal regions of India.
- Sea Level, Cyclones, Storm Surges, Waves, Ecology
- Modelling and Deep Ocean Observing Framework.

Participating Institutions:

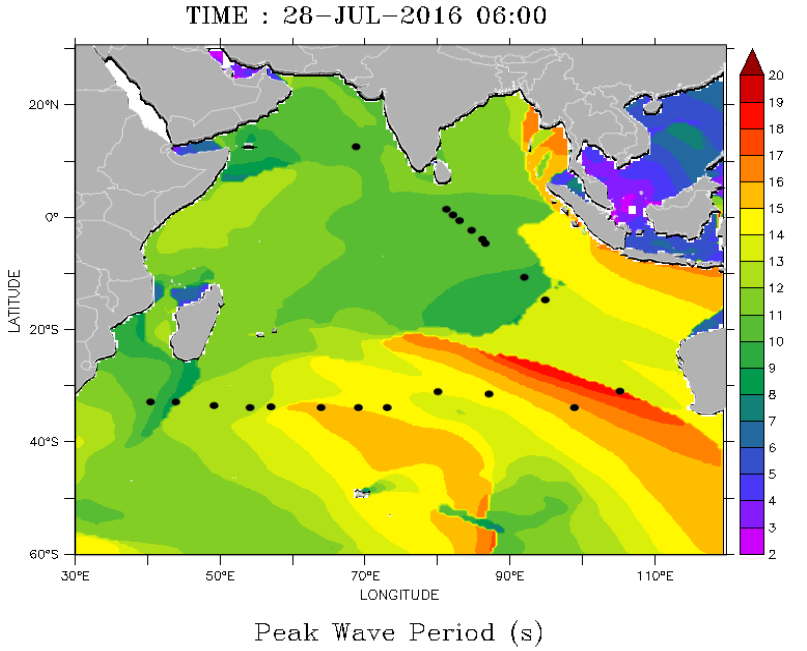
INCOIS, IITM, NCCR, NIOT, NCPOR, IITs, SAC, NIO, IISc, MoEFCC, Navy, Industry, Others

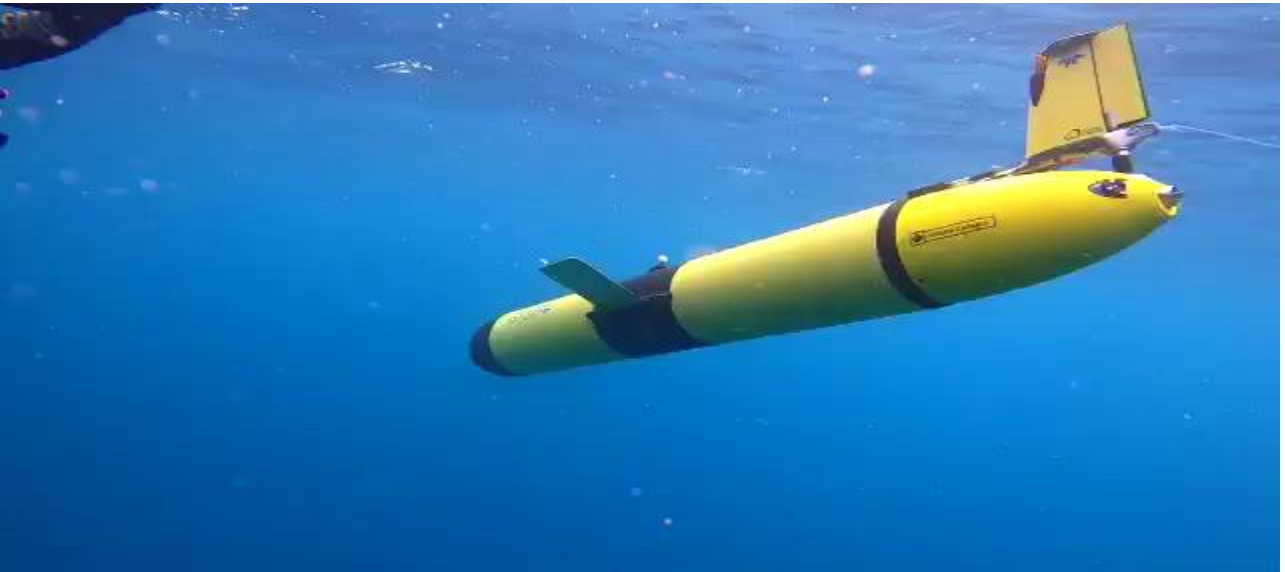
Deep Ocean Observing System

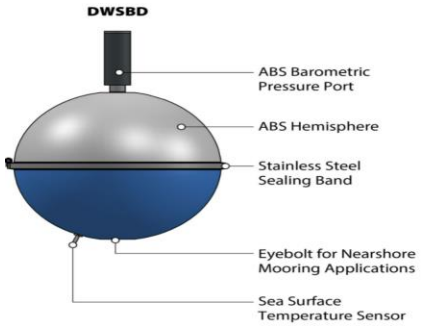


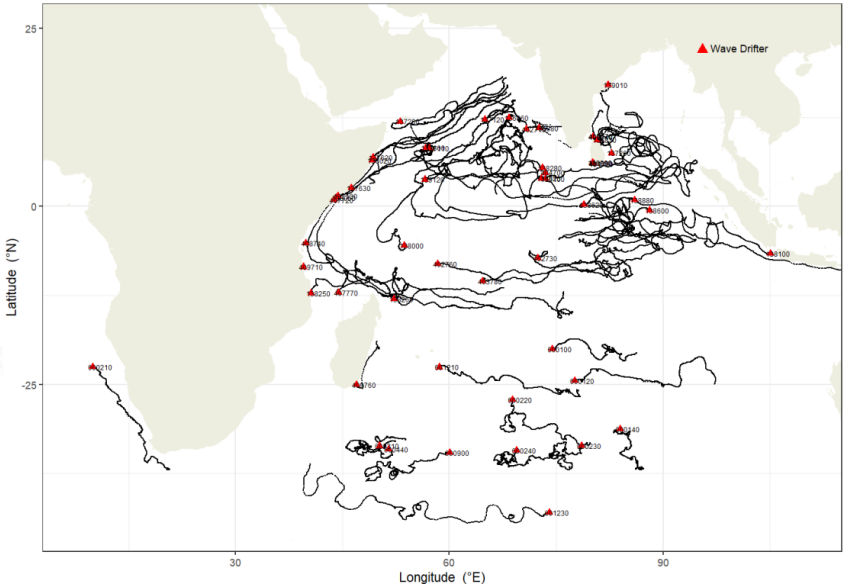
S. No	Glider-ID	Deployment Date	Recovery Date	Ops Days	Region	Scientific Parameters Measured				
						CTD	PAR	DO	Chlorophyll-a	Turbidity
1	891	5 Mar 2021	20 May 2021	76	North Bay of Bengal	✓	✓	✓	✓	
2	891	8 Mar 2023	20 Apr 2023	43	North Bay of Bengal	✓	✓	✓	✓	
3	1096	23 Sep 2023	23 Mar 2024	182	North Bay of Bengal	✓	✓	✓	✓	✓
4	1128	27 Apr 2024	9 Jan 2025	257	North Bay of Bengal	✓	✓	✓	✓	✓
5	890	5 Mar 2021	18 May 2021	74	South Bay of Bengal	✓	✓	✓	✓	
6	890	8 Mar 2023	7 Jul 2023	121	South Bay of Bengal	✓	✓	✓	✓	
7	1095	23 Sep 2023	23 Apr 2024	213	South Bay of Bengal	✓	✓	✓	✓	✓
8	1130	27 Apr 2024	30 Nov 2024	217	South Bay of Bengal	✓	✓	✓	✓	✓
9	1127	27 Oct 2023	28 Jun 2024	245	North Arabian Sea	✓	✓	✓	✓	✓
10	1127	2 Jul 2024	10 Jul 2024	8	North Arabian Sea	✓	✓	✓	✓	✓
11	1131	30 Jan 2024	16 Oct 2024	260	South Arabian Sea	✓	✓	✓	✓	✓
12	1129	26 Dec 2024	1 May 2025	126	Off Mauritius	✓	✓	✓	✓	✓
13	1126	3 Feb 2025	7 Apr 2025	63	Antarctica	✓	✓	✓	✓	✓

*Glider 1129 is still in water off mauritius and total operational days can be determined after the recovery.

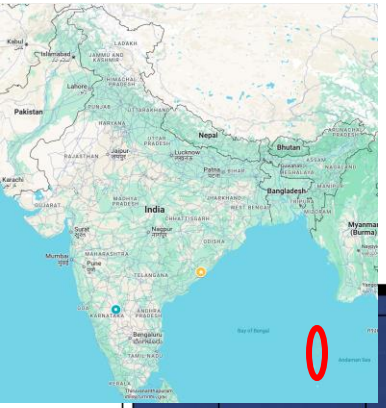


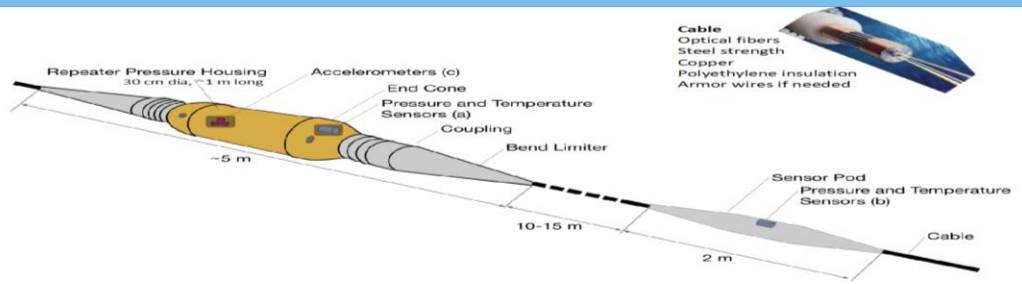


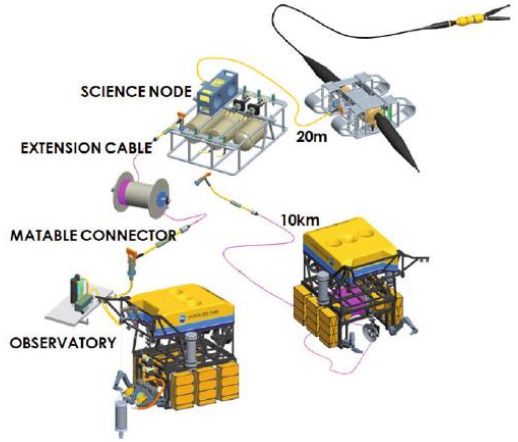


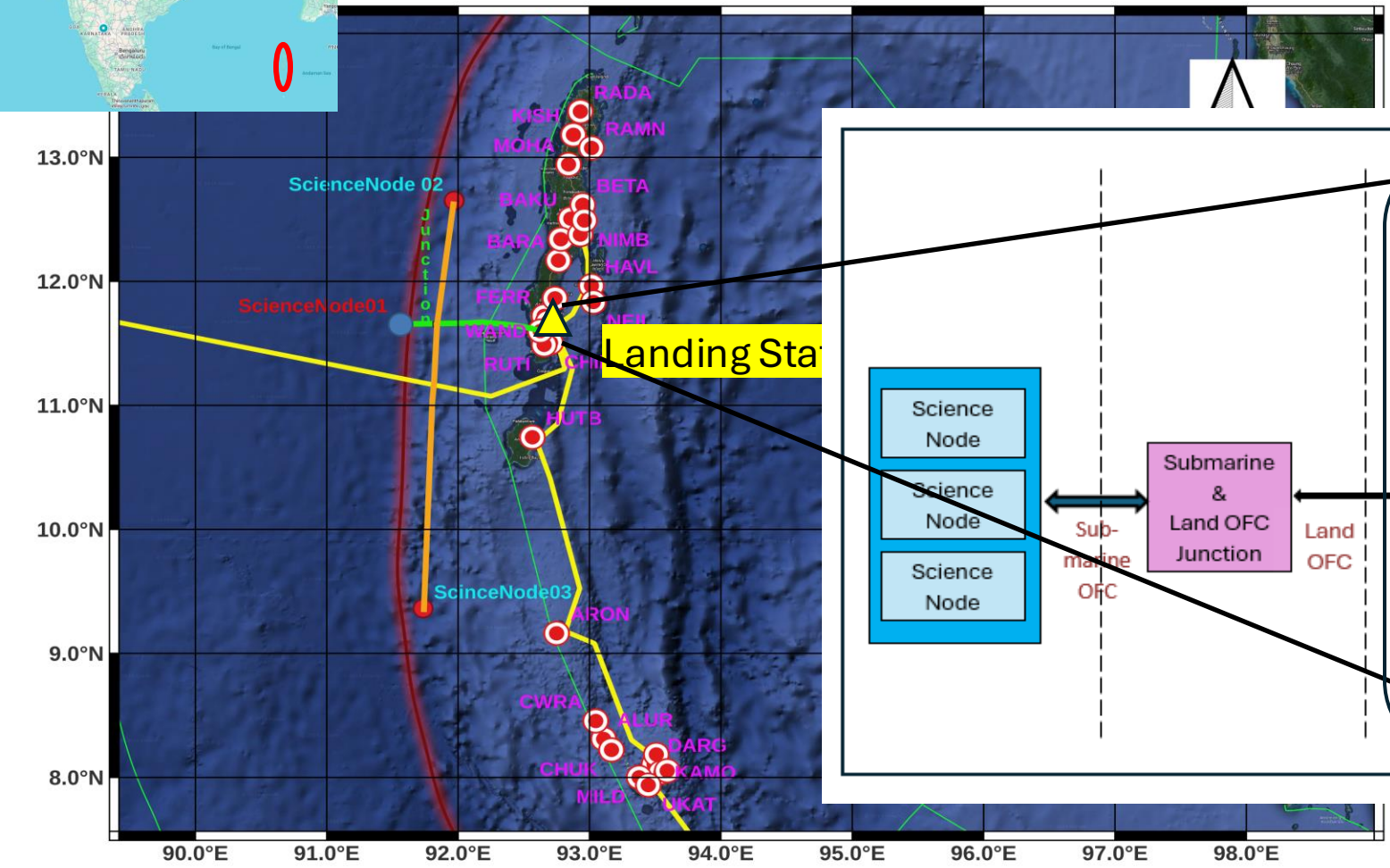


Submarine multiparameter cabled observatory

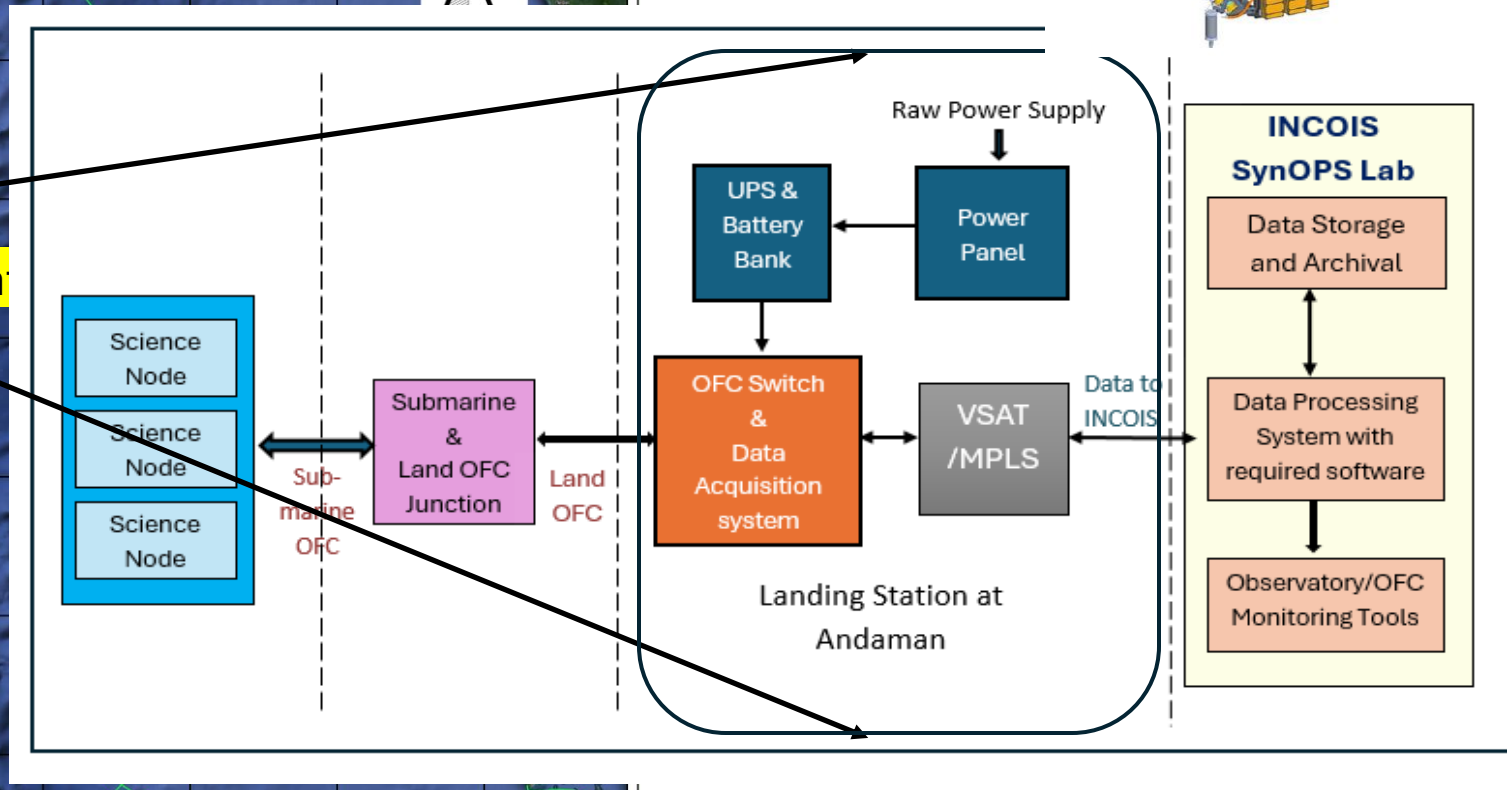






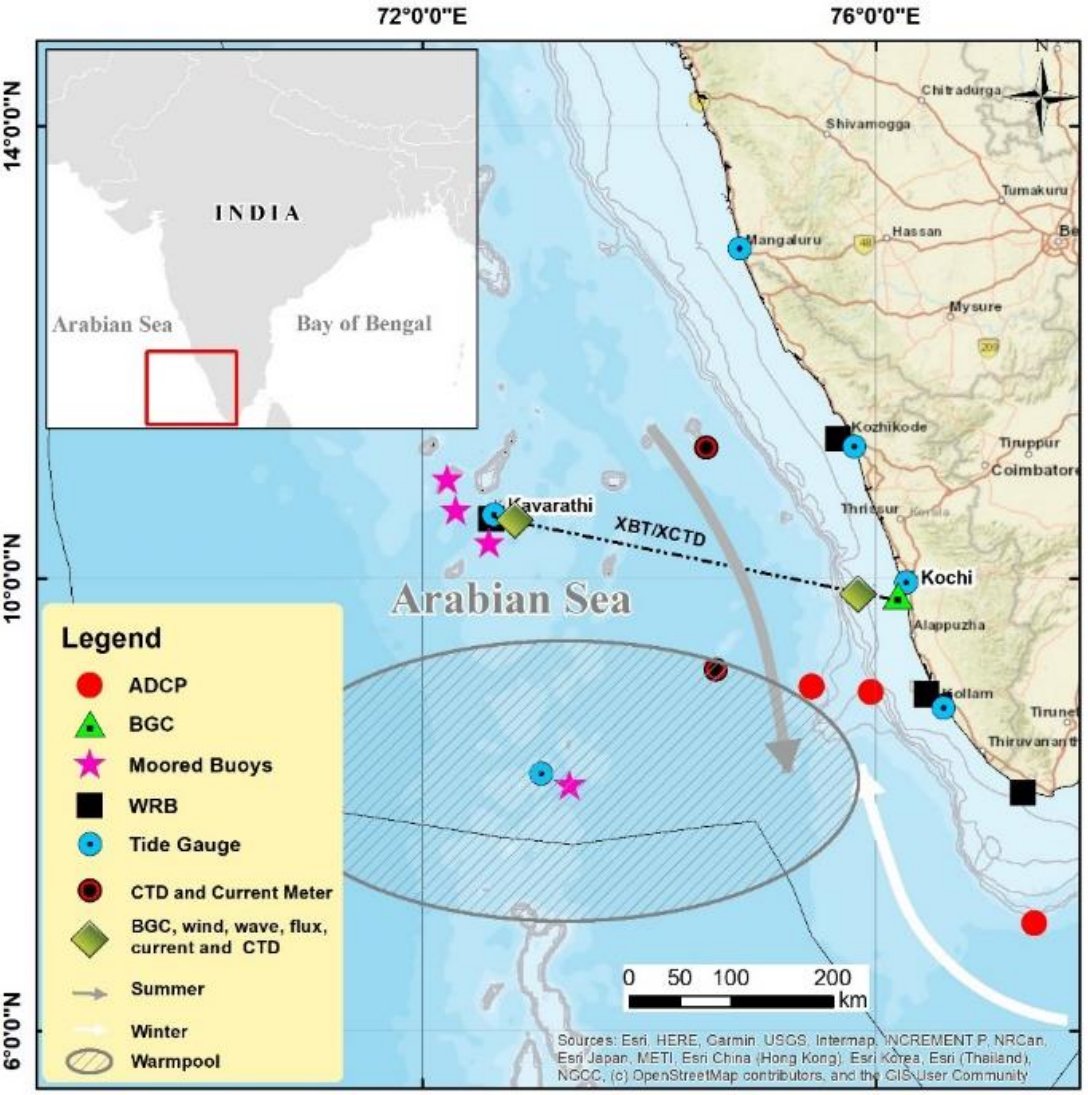


Landing Sta

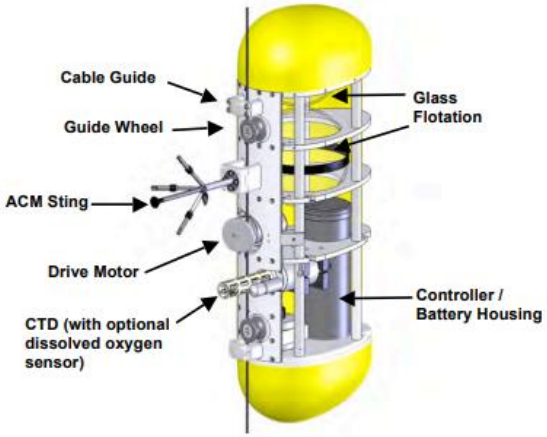


National Coastal Mission

"Observational Testbed – Towards augmenting sustained observations for understanding and prediction of coastal processes to enhanced and strength ocean services"

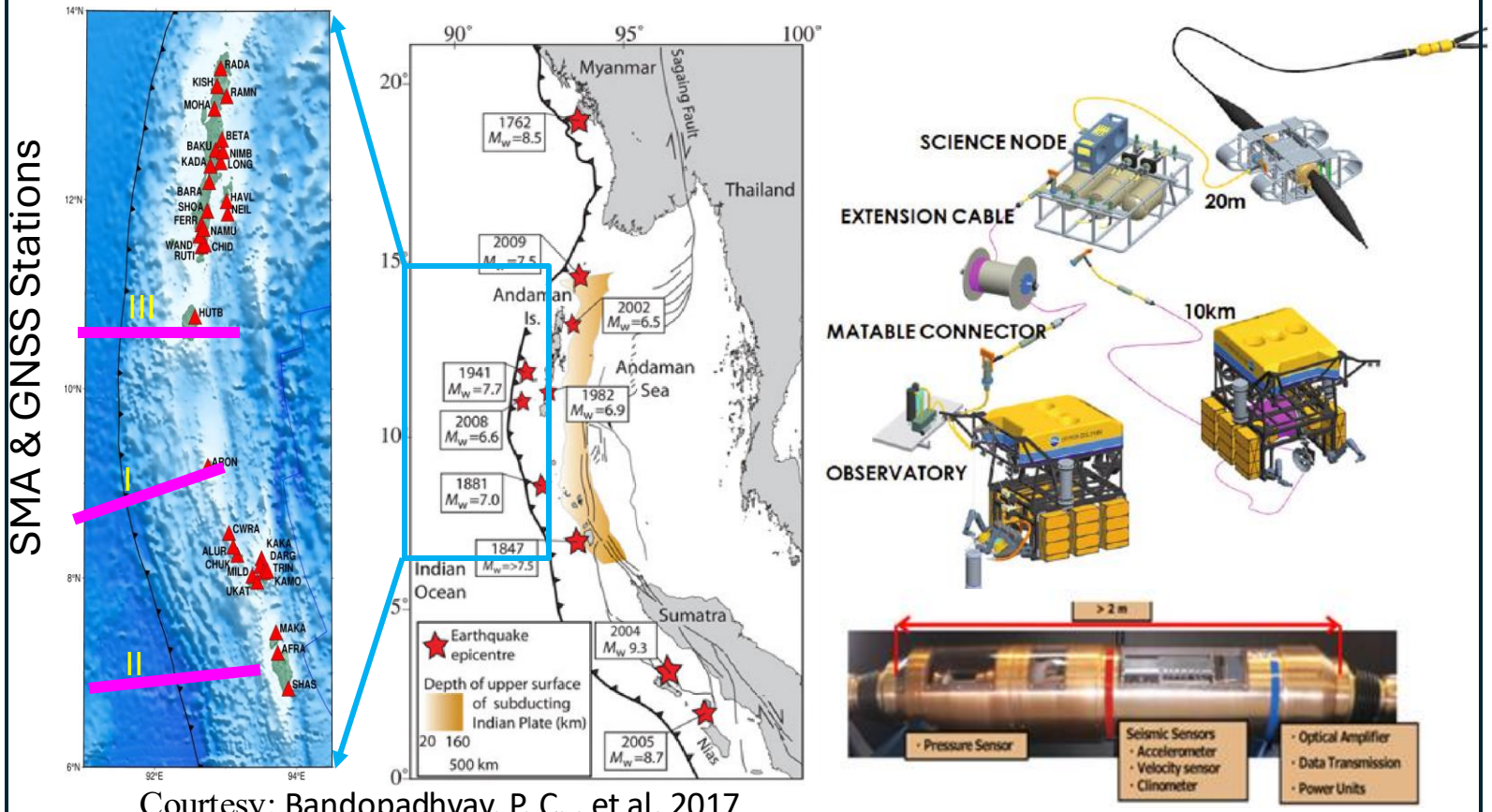


- ✓ Validation, improvement and development of ocean models for prediction of climate scale variables
- ✓ Cal/Val site of satellite data for operational applications
- ✓ Understating and prediction of the coastal processes such as hypoxia, ocean acidification, sea level rise, water masses and their inter-basin transport, air-sea interaction etc



New Programs

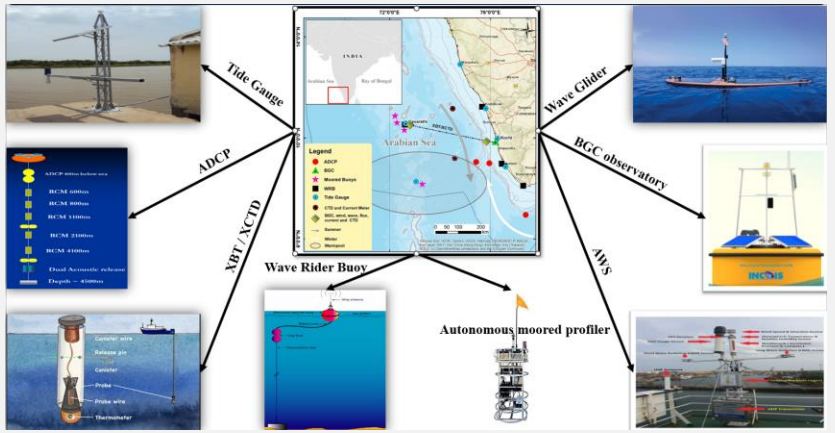
Submarine Cabled Observatory at Andaman & Nicobar Islands



Courtesy: Bandopadhyay, P. C. , et al, 2017

- Prioritized the location to lay the cables based on the historical tsunamis and tsunamigenic earthquakes in the area
- Identified scope of work and sensors (Ocean Bottom Seismometers, Bottom Pressures Recorder, Clinometer, Ambient noise & C-T)

Coastal Test Bed



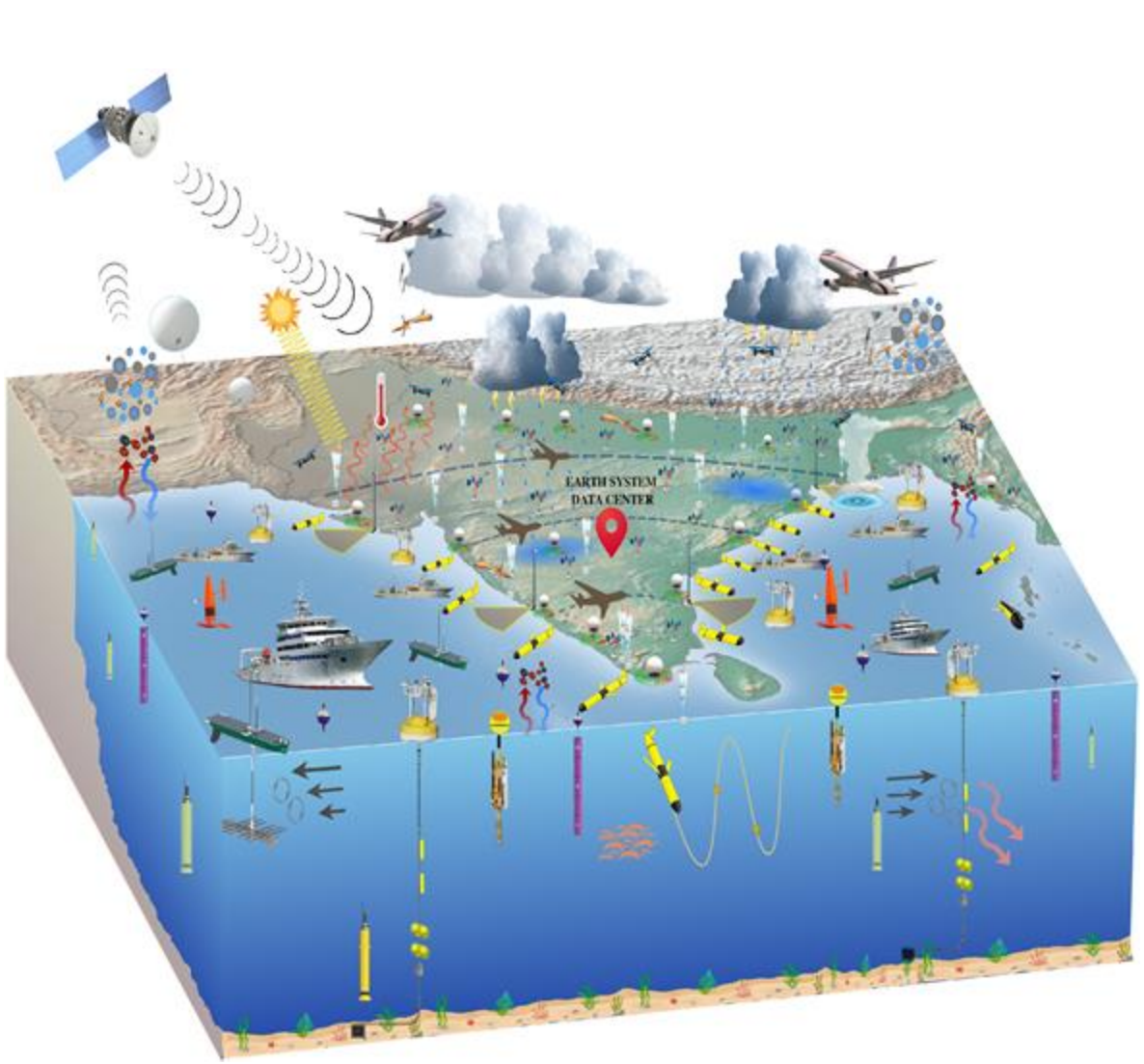
Towards augmenting sustained observations for understanding and prediction of coastal processes to enhanced and strength ocean services

A sustained observation network with new age platform that will provide climate scale observations.

- Long-term in situ data of physical (air sea fluxes and hydrography) and biogeochemical parameters.
- A test-bed for development, improvement and validation of ocean models and calibration and validation site for satellite data.
- Capacity development in designing, deployment and maintenance of the ocean observing platforms as well as in data processing, handling and quality check

The proposal submitted to Ministry of Environment, Forest and Climate Change under National Coastal Mission

INCOIS's Role in Mission Mausam



Mission Mausam, led by the Ministry of Earth Sciences, aims to make India a weather-ready and climate-smart nation. MoES will equip the country with the tools to predict weather events, provide timely warnings, ensure better preparation for the challenges ahead, and create a safer and more climate-resilient nation for all through the enhancement of observational and modelling infrastructure

INCOIS's Role in Achieving Mission Mausam's Goals

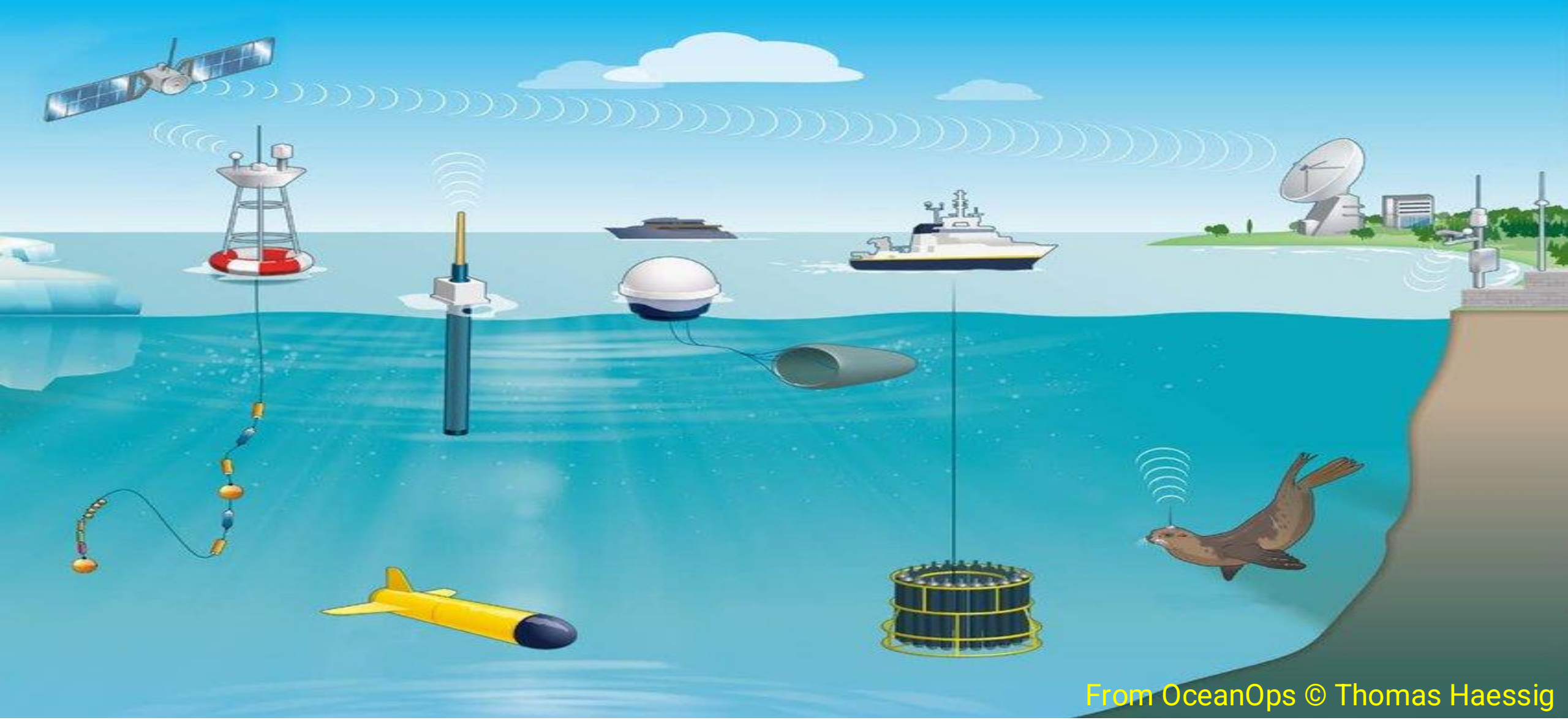
In-situ Ocean Observations to promote cutting-edge research on dynamics of Monsoon and Tropical Cyclone.

- Implementation of state-of-the-art upgraded Automatic Weather Stations equipped with upper-air observations.
- Development of an Ocean Research Station in the Bay of Bengal.
- Lead national ocean observation campaigns for monsoon and extreme weather event studies.

Earth System Data Management to support enhanced operational weather predictions and disaster management.

- Establish a centralized data assembly facility for Earth system data featuring a digital twin capability
- Enable real-time data access with digital twin capability for comprehensive monitoring and decision-making.
- Facilitate critical data sharing for stakeholders involved in operational weather predictions and disaster management

पृथ्वी विज्ञान मंत्रालय
MINISTRY OF EARTH SCIENCES
सत्यमेव जयते
NCMRWF
NCPOR
NIOT
NCCR



Thank You