



UNRAVEL THE MYSTERY OF CLOUDS

Dr **SHAILESH NAYAK**, Secretary, the Ministry of Earth Sciences (MoES), talks to **RAIL BANDHU** about new projects on predicting weather, joint initiatives, with other nation and reversing brain drain

When will India have its own weather model that can help predict accurate weather conditions?

India will have its own weather and climate prediction models by 2017. Under the Monsoon Mission, ESSO-MoES has initiated research and developmental work to develop state-of-the-art coupled models for improved monsoon predictions on all time scales (short-range to seasonal time scales). For this purpose, two global climate models, viz, the Climate Forecasting System (CFS) model and the UK Met office model were adopted. Research and developmental work is being done to improve the skill of these models. This effort will include advanced data assimilation methods, better physical parameterisation schemes and better post-processing methods. It is expected that these models will be ready by 2017.

Scientists are conducting experiments in the seas surrounding India to understand the monsoon in an attempt to develop improved rainfall prediction models. Please elaborate on this project.

ESSO-MoES has built an observational programme over the Bay of Bengal to understand the coupled physical processes and monsoon air-sea interaction. The main aim of the programme is to obtain multiscale near-surface observations, reference surface flux dataset, and observations in the atmospheric boundary layer across seasons. Various moorings, drifters and profiling floats have been deployed to provide continuous observations. Ship-based intensive observation will be made in 2014 (monsoon season), 2014-15 (winter), 2015 (summer) and 2015 (autumn or post-monsoon season).

The improved understanding of physics in the coupled boundary layers of the ocean and atmosphere will help improve monsoon prediction in all time scales. This will also facilitate in building basic infrastructure and capacity in dealing with fine-scale observations and modelling through international collaboration.

What all scientific activities are studied at Bharati station in Antarctica?

At the Bharati station, multi-disciplinary studies are carried out, related to snow and ice, geology, paleoclimate and ecosystem.

- Assessment of polar ice dynamics using remote sensing data and in-situ observations.
- Glaciological studies for assessing the impact of climate change.
- Biogeochemical studies of Antarctic snow to understand the influence of biogeochemical processes on cryospheric system.
- Geological studies of the Larsemann Hills area focussing on the tectonic evolution of East Antarctica.
- Paleoclimatic history of East Antarctica from proxy records in the sediment cores

retrieved from the lakes in the Larsemann Hills.

- Long-term monitoring of wildlife and their habitats in the area around Larsemann Hills.
- Hydrographic surveys of the off-shore areas of Larsemann Hills.
- Environmental monitoring of the Bharati Station and its surroundings as a continuing programme.

India has recently signed a Letter of Intent (LOI) with Japanese Agency for Marine-Earth Science and Technology (JAMSTEC). Please tell us about it.

The focus areas of this LOI is to carry out joint research activities in the areas of ocean and earth science and technology, especially geophysical study in Indian Ocean (Andaman subduction zone, geoid anomaly, *et. al.*), deep sea technologies, ocean observations and climate variability.

India and France are also coming up with a joint initiative to predict the monsoon better than extant systems. Please tell us about it.

The Ministry of Earth Sciences (MoES) is a member of the Belmont Forum. Created in 2009, the Forum is a high level group of the world's major and emerging funding agencies of global environmental change research and international science councils. To carry out joint collaborative work on environmental issues, Belmont forum identifies Collaborative Research Action (CRA) areas every year, under which transnational proposals with participation of minimum three countries are invited.

During 2014, MoES along with ANR France is launching a CRA on "Climate Services and inter-regional linkages". Under this, collaborative activities will be undertaken to understand the role of polar regions and other mid-latitude systems on the global monsoon, in the sub-seasonal to decadal scale. The outcome of the research will help in delivery of better climate services.

You have come up with text book series for graduate students in Earth Sciences. How will it fill the knowledge gap among undergraduate students for motivating them to choose science as their career discipline?

To encourage research in geosciences and also to augment capacity-building in the field of Earth Sciences, the Ministry gave financial support to the Indian Institute of Technology, Roorkee for writing a 'text-book series for the graduate students in Earth science'. The proposal aims to fill in knowledge gaps for the Earth Science graduate students by providing a set of 14 affordable and illustrative text books with examples that are India-centric. The books are written in simple form and will be published by the Geological Society of India. Three text books on crystallography and mineralogy, elements of palaeontology and an introduction to structural geology have already been published.

What is the Ministry doing to encourage students to become scientists? How are you planning to reverse drain brain?

We have been participating in the International Earth Science Olympiad (IESO) to encourage students and develop public awareness of earth science, so as to motivate them to learn earth sciences and to opt earth system science as their possible career option. National level competitions are organised to select a team to represent India. India has been winning silver and bronze medals. The 7th International Earth Science Olympiad (IESO) was held between September 11 and 19, 2013 in India. MoES has a scheme for establishment of visiting chair professors in various premiere institutes of the country. Under this scheme, eminent scientists/professors/engineers with international acclaim are invited for a period of two-three months every year. Currently, IIT-Delhi, Kanpur, Kharagpur, Gandhinagar have been participating.



See it to believe it

Be it exploring the depths of ocean beds of the country, making India's presence felt in the polar limits of the earth or monitoring of glacial summits of Himalayas — the Ministry of Earth Sciences (MoES) has done the nation proud with its diverse array of achievements. And most importantly, results of its high tech, state of the art research are not simply confined to the world of scientific and abstruse jargons, but its impacts are disseminated to the remote corners of the country for the benefit of common man

Safe and sound

It is due to the Ocean State Forecast services developed by the Indian National Centre for Ocean Information Services (INCOIS) that administrators and fishermen can plan their activities better and keep off dangerous sea conditions



The Ministry has been consistently upgrading its mechanisms for imparting more accuracy in its forecasting of the various forces of nature. But nothing can be as challenging than the prediction of the vagaries of the sea. India is endowed with the longest coastline in the world stretching for over 7,500 km (including Andaman, Nicobar and Lakshadweep Islands) where advance projection of the situation involves a tremendous sense of responsibility.

Wide spectrum of maritime operations are carried out in this part of our country. This ranges from traditional fishing to high tech oil exploration. Then dotting the country's coastline are numerous ports which are abuzz with round the clock economic activities. To add to them are ongoing marine research, and defence projects besides contingency search and rescue operations in the sea and oil spills.

Keeping this in mind, Earth System Science Organisation — Indian National Centre for Ocean Information Services (ESSO-INCOIS) established the integrated Indian Ocean Forecasting System (INDOFOS). The system is capable of predicting the surface and subsurface features of our oceans reasonably well in advance of 5 to 7 days.

In this regard, one critical factor is information on various parameters of the state of sea in the vicinity — as for example locally generated wind waves, remotely generated swell waves, currents, winds and tides. Be it the entry and exit of a small

fishing boat or that of large vessels to the port, pre information of such conditions largely eliminate the sense of risk or inherent fear in undertaking such activities.

Another subtle application of this forecast is in the sphere of recreational sea side tourism. Some of these locations have recently introduced sea planes, along the coastline. INDOFOS successfully enables the scientists to know of cyclones and other extreme situations, in advance, on the basis of which alerts are issued to the general public as well as the administrators of the coastal stretch under threat such that the concerned population is relocated to safer places.

Further, ESSO-INCOIS not only provides ocean forecasts for the Indian waters of Arabian Sea, Bay of Bengal, Northern Indian Ocean, Southern Indian Ocean but its expertise also stretches beyond as far as Red Sea, Persian Gulf and South China Sea.

Taking into consideration the specific requirements of the various users, new products are being constantly developed and customised like forecast along the ship tracks, web map services and forecast for ports and harbours. The High Wave Alert service is another important and popular service of INCOIS issued during cyclones as for example during Phailin, October, 2013 and other extreme events.

The prediction of state of sea has been further supplemented with various novel initiatives in ocean technology. A Wave Atlas

for the Indian coast has been published by the ESSO-National Institute of Ocean Technology, Chennai.

This atlas is a reference for basic information related to various aspects of wave that has been put in public domain. The data covers major portion of Indian Ocean, Bay of Bengal and Arabian Sea, analysed over a period of 15 years. Most importantly, it also provides long-term estimate as probable maximum wave height at a user selected location for the next 50 to 100 years for the purpose of planning. The atlas gets updated on routine basis.

Being an unrestricted open access database, the atlas will benefit entrepreneurs, researchers, students and practicing engineers in coastal projects as the first source of scientifically produced marine information.

Last year, Ocean State Forecast System was inaugurated 14 km off Puthiyappa harbour in Kozhikode. INCOIS, in association with Centre for Economic and Social Studies, launched the venture on a daily operational basis. It has three parts — observatory, forecast and dissemination. The first unit known as wave rider buoy assesses the state of waves and sea surface temperature. The data collected through this mechanism will be used for forecasting the climate. It will later be disseminated using radio, TV and mobile phone. People could be forewarned about the impending high winds and high waves with this system.



In the middle of the World

Moored buoys have revolutionised the observing system capabilities and made a global system possible. Under the Ocean Observation Network (OON) programme of ESSO MoES, the OOS team has established Tsunami Buoy System and Bottom Pressure Recorders (BPRs) in the Indian Seas

The Ocean observation systems (OOS) group of National Institute of Ocean Technology (NIOT) is entrusted to undertake the activities on moored buoy programme.

The OOS group, erstwhile National Data Buoy Programme, was established in 1996, with the objective to operate, maintain and develop moored buoy observational networks and related telecommunication facilities in the Indian seas. Later, OOS has inherited lead responsibility for a number of important and well-established observational programmes in the northern Indian ocean. Due to the remoteness of the vast open oceans, there have been a challenge to continuously observe them, which was later harmonised by in-situ and satellite-based observations.

At present, OOS has established sustained moored buoy network for oceanographic, marine meteorological and tsunami warning applications. Moored data buoys are offshore floating platforms, fitted with meteorological and oceanographic sensors, moored at specific locations to observe in situ met ocean data at regular intervals. The observed data is then transmitted through satellite along with location reference, in synoptic hours, to the state-of-the-art shore station facility at NIOT, Chennai.

The next generation of buoy systems called OMNI Ocean Moored buoys in the northern Indian Ocean are equipped with high-tech sensors to measure ocean currents, conductivity, and temperature up to 500 m

depth along with solar radiation, precipitation and transmit data in real time through satellite.

As challenges arise in the form of natural disasters, OOS is now entrusted to deploy buoys capable of reporting water level for Tsunami Early Warning System. OOS team has developed, tested and established Tsunami Buoy System and Bottom Pressure Recorders (BPRs) in the Indian Seas.

In addition, OOS has established and maintaining CAL VAL Buoy system for satellite data validation in collaboration with SAC ISRO. Further indigenous developments are being undertaken and many such units and sub components developed are working successfully at sea. Indian moored OMNI buoy system with sub-surface sensors is developed and is being tested at sea. Coastal buoys are installed at four locations viz Goa, Port Blair, Agatti and Krishnapattinam and are working using INSAT and GRRS communication system. Data sets are being analysed in house.

Also OOS has joined NCAOR on projects such as southern ocean mooring system and Arctic mooring system. Efforts are being taken for development of autonomous ocean observation tools such as ROBOFISH, and variable buoyancy modules. The most important aspect of OOS is the real time dissemination of data, especially during extreme weather conditions. The shore station is manned 24x7 and the data obtained from moored buoy network are disseminated in real time INCOIS.





The deployment of the country's first polar mooring is a testimony to the capabilities of Indian organisations in designing, developing and installing underwater observatories. Take a look

A major milestone in India's scientific endeavours in the Arctic was recently achieved when a team of scientists from the ESSO-National Centre for Antarctic and Ocean Research (NCAOR) and the ESSO-National Institute of Ocean Technology (NIOT) successfully deployed IndARC, the country's first multi-sensor moored observatory in the North Pole.

This system will provide an understanding of the response of the Arctic to climatic variabilities and their influence on the Indian Monsoon system.

Designed and developed by scientists from the National Centre for Antarctic and Ocean Research (NCAOR) and National Institute of Ocean Technology (NIOT), the observatory has been deployed in the Kongsfjorden fjord of the Arctic.

Giant strides are also being taken to unravel the mysteries of the polar science. ESSO-National Centre for Antarctic and Ocean Research (NCAOR) and the ESSO-National Institute of Ocean Technology (NIOT) has achieved a major milestone in the Arctic region on July 23, 2014 when a team of scientists successfully deployed IndARC. It is the country's first multi-sensor moored observatory in the Kongsfjorden fjord of the Arctic, roughly half way between Norway and the North Pole. Fjord is a long, narrow inlet with steep sides or cliffs, created by glacial erosion.

This moored observatory is at present anchored about 1,100 km away from the



North Pole at a depth of 192 meters. It has ten state-of-the-art oceanographic sensors strategically positioned at different depths in the water column. They are programmed to collect real-time data on seawater temperature, salinity, current and other vital parameters of the fjord.

The expeditions to Himadri, the country's first research station at Ny-Alesund in Svalbard in Arctic region of Norway have also gathered momentum. The 8th expedition to Himadri is currently underway from July which is expected to conclude in October, 2014. Himadri is gathering research data on aerosol radiation, space weather, microbial communities, glaciers, sedimentology, and carbon recycling amongst others.

The Arctic Ocean and its surrounding regions are significant in not only governing the earth's climate but it also enable us to have an idea of "Paleo" or past climate.

These ice cores in the course of their formation since the past 600,000 years has continued to trap in air of the respective periods. These air samples form interesting subjects of study.

The region is also an excellent harbinger of future changes, as the signals or clues that signify climate change are much stronger in the Arctic region than anywhere on the planet. It has always been important to the Indian subcontinent due to its possible connection with the intensity of Indian monsoon that is crucial is critical for our agricultural output and economy.

Expeditions to Antarctica on the other hand are much older that has led to the setting up of permanent stations as "Dakshin Gangotri" (1983-88) and "Maitri" (1989 - till date). These enable the experts to record round the year observations in the region.

The environment in Antarctica is very pristine. In order to catalyze and consolidate the gains accrued from the various Antarctic expeditions and to stimulate research in the frontier areas of Polar and Ocean Sciences, "Antarctic Study Centre" was established at Goa in 1988. This Centre was renamed as "National Centre for Antarctic and Ocean Research" (NCAOR) on April 5, 1999. For the first time in the country polar and R&D laboratory was set up at NCAOR. This complex maintained at -25 degree C has been established for the preservation and analysis of ice core and snow samples, not only from Antarctica but also from Himalayas.

After Earth

CMLRE has been organising, co-ordinating and promoting ocean development activities in the country which inter-alia include mapping of the living resources, preparing inventory of commercially exploitable living marine resources, their optimum utilisation through ecosystem management and R&D in basic sciences on Marine Living Resources and Ecology.

One striking example is the Ministry's people friendly innovative strategies to promote large scale fish production through mariculture. This has not only improved the quality of life of millions of coastal fishermen of the country but is also emerging as the viable option to cope with the growing demand for fish proteins in the country.

MoES with its allied organisations also came to the rescue of several fishing villages in Puducherry which had been reeling under the constant threat of severe coastal erosion. This resulted in huge loss of assets and property of the fishermen calling for immediate remedial action. The solution was found in "beach nourishment" whereby sustainable measures are taken by dumping or pumping sand from elsewhere onto an eroding shoreline to create a new beach or to widen the existing beach addressing the problem of coastal erosion in the Union Territory. The pilot project has shown a gain of beach width to an extent of 60m.

Exploring new vistas in fishery is another forte of MoES. One such way is cage farming of fish on sea. In this process, rearing of fish in an enclosed area in a natural aquatic environment where there by a continuous flow of water. Hence, this does not allow the accumulation of debris and there by no pollution or ammonia deposition as in the case of stagnant and low density water ponds. The young ones of fish and other aquatic species are kept, fed and grown to marketable size in such cages.



The Centre for Marine Living Resources & Ecology (CMLRE) is a research institute under the Ministry of Earth Sciences to study marine living resources. Apart from implementing various research projects, the institute also manages and operates the Fishery Oceanographic Research Vessel (FORV) Sagar Sampada



This is a relatively recent aquaculture technique, which gives nearly tenfold increase in catch of fish as compared from ponds or wild harvest in the sea. Realizing the vast Exclusive Economic Zone of the country and the huge demand for fishery products, Earth System Sciences Organization - National Institute of Ocean Technology (ESSO-NIOT) has designed, developed, deployed and tested High-Density Polyethylene fish cages with a diameter of nine metres in the North Bay (Andaman Islands), Olaikuda (Tamil Nadu) and Kothachathram (Andhra Pradesh).

The experiments were undertaken in various conditions including fully protected, semi-protected and open sea environments. The technique worked wonders in the culture of several species of marine fin fish, such as the Asian Seabass cobia, Pompano Milkfish, Parrot fish and the Giant Travelly. As an example, from barely 5-8 gms of seeds of

milkfish a total of 3.5 tonnes of milkfish was harvested in open sea cages at Okaikuda village off Rameshwaram coast in Tamil Nadu.

The Marine Living Resources Programme envisages survey, assessment and exploitation of the MLR and studies on its response to changes in the physical environment. The aim is to develop an ecosystem model for the management of the living resources in the Indian EEZ.

CMLRE manages FORV, an Indian research vessel that is equipped to carry out multi-disciplinary research in oceanography, marine biology and fishery science. The FORV Sagar Sampada is fully utilised for these studies. On-going MLR surveys in the EEZ focus on deep sea fishery, tuna-resources, harmful algal blooms, bioluminescent planktons, marine mammals, environment and the productivity patterns. These efforts are complimented through allied activities under MLR namely studies on the benthos of the continental slope area, studies on biodiversity of planktons in Andaman sea, studies on the near-shore dynamics with special reference to upwelling and mud-banks, application oriented R&D on production of pearls from the black-lip pearl oyster, and technology development of marine ornamental fishes.