Nansen Environmental Research Centre (India)
A non-profit research centre for Environment, Climate and Energy research in the Nansen Group of Norway

Annual Report 2005-2006
Activity report

Vision

Make a significant contribution to environmental and earth sciences research and application in India through local capacity building as well as increased regional and international cooperation.

Main research focus areas are:
- Numerical Ocean Modelling
- Satellite Remote Sensing and GIS Applications
- Coastal Zone Management
- Appropriate Technology for Sustainable Environment Development

NERCI has expertise in development and implementation of algorithms for satellite remote sensing data analysis, numerical ocean and coastal models for eco-system studies as well as data assimilation techniques with the technical support of Nansen Group of institutions in Norway, UK, Russia and China.

Organization


The Nansen Centre India conducts basic and applied research in Ocean Sciences mainly funded under contractual research projects and by NERSC, Norway and exploring possibilities of funding from international agencies and research councils to become self reliant.

Staff

Nansen Centre (India) currently functioned by three full time scientific staff with two consultant scientists and four administrative staff on part time basis. At the end of 2005, two Indian students have been admitted to conduct doctoral programme at NERSC and Geophysical Institute, University of Bergen, Norway and be inducted into the main stream research activity of NERCI after completion of their Doctoral degree. The scientific research advisory board was consulted for taking guidance for R&D activities and promotion of education and social interaction with institutes in India and abroad.

Office and Environment

NERCI has renovated its office with improved facilities and working environment with the support of NERSC, Norway. The office conditions are satisfactory to accommodate more scientific staff envisaged in coming years. The activities of the center does not cause any damage to the local environment.

The Doctoral Fellowship program

The Doctoral fellowship program of two students Mr. Rahman Mankettikara and Ms. Mary Swapna George is funded by NERSC/Mon-sverdrup Center, Norway and by private donation from Mr. Trond Mohn c/o Frank Mohn AS for the Doctoral degree from University of Bergen in the following topics:

1. Validation of the HYCOM model for the Indian Ocean region and mesoscale ocean studies of the area
2. Data assimilation into the HYCOM model of the Indian Ocean.
Nansen-Nerci short term fellowship

NERCI has introduced Nansen-Nerci short term fellowship from 2006 for outstanding young postgraduate students in Oceanography / Ocean Technology from India. Mr. Roshin P. Raj from Dept. of Physical Oceanography, Cochin University of Science and Technology has been nominated for this fellowship for the current year.

Financial Situation

NERCI is a non-profit research center registered in India in 1998 under Article 25 of the companies Act and no dividend is shared between the shareholders. The Centre does not receive any basic governmental funding but has been registered under Educational and Social category in the Ministry of Home Affairs, Govt. of India to receive international funding.

Mr. A. Mohanan, B.Sc., F.C.A, M/s. Balan & Co. is the official chartered Accountants and auditor of NERCi to monitor and file returns in governmental matters. The authorized share capital of NERCI is INR. 2,000,000/- as on 31.3.2006 and the accrued expenditure for the period 1.4.2005 to 31.3.2006 is INR. 380,677/- as per the audited balance sheet of the Centre. NERCI is also registered as a charitable institution under section 12AA of the Income Tax act of Govt. of India.

Prospects for 2006-2007

NERCI expects a substantial expansion in its research activities in 2006-2007 due to increased cooperation, man power and projects to be submitted during this period.

It is expected to start external funded projects in the year 2006-07 with new projects kick off. NERCI has already submitted projects to agencies like Norwegian Research Council, British Council and Asia Pacific Forum for Environment Development in the tune of INR. 25,00,000/- for the current year. It is expected to have moderate increase in its project income in the coming years through funding from Norwegian Ministry of Foreign Affairs, European Union, World Bank, India-Australia Strategic Fund scheme and National Science and Technology Management Information System of Dept. of Science and Technology, Govt. of India.

National and International activities

- NERCI has launched its website www.nerci.in for global outreach of its activities and the site is maintained by M/s. ArideOcean, Cochin.
- NERCI has entered into a consortium with Centre for Earth Research and Environment Management, a scientific society to take up joint projects in India, www.ceremindia.org
- Registration of NERCI is in progress in the Consultancy Development Centre, an autonomous institution promoted by Dept. of Scientific and Industrial research (DSIR), Ministry of science and technology, Govt. of India.
- A research proposal under the UK-INDIA Education and Research Initiative (UKIERI) in collaboration with Coastal Engineering Group, University of Plymouth is under consideration for initial funding for project formulation.
- Proposal under the BILAT2007 for Indo-Norwegian institutional cooperation in operational oceanography and climate research in cooperation with NERSC, Norway, was submitted by NERSC, Bergen to Research Council of Norway.
- Proposal to APFED (Asia-Pacific Forum for Environmental Development, Japan) is under consideration for the project on “Water quality monitoring and low cost purification strategies for inland waterways of low-lying areas”.
- Proposals with budgets INR. 120,00,000/- are in different stages to be submitted to World Bank and also under India-Australia Strategic Research Fund schemes and DST-NSTMI, Govt. of India.

International / National Collaborating Partners

NERCI has established initial cooperation in collaborative research with the following institutions.

- Nansen Environmental and Remote Sensing Centre, Bergen, Norway
- Coastal Engineering Group, University of Plymouth, UK
- School of Earth Sciences, University of Melbourne
- Indian National Centre for Ocean Information Services, India
- National Institute of Oceanography, India
- Space Application Centre, ISRO, India
- Cochin University of Science and Technology, India
- Centre for Earth Science Studies, Kerala, India
- Central Institute of Fisheries Technology, India
- Central Marine Fisheries Research Institute, India
- Centre for Earth Research and Environment Management, India
- Anna University, Chennai, India
Scientific Report

Synergistic use of Ocean colour, Satellite Altimetry and AVHRR data for the studies of upwelling and Chlorophyll productivity in the Northern Indian Ocean

Prasanth, D., Research Fellow, Dr. K. Ajith Joseph, Senior Scientist, NERC

Upwelling is an oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-deplete surface water. The coastal areas of the Arabian Sea are major zones of upwelling during the SW monsoon (Currie et al., 1973). Particularly off the Arabian coast (Oman coast), upwelling is observed to extend 400 km offshore and runs parallel to the coast for nearly 1000 km. This area shows the maximum abundance of phytoplankton and zooplankton in the Indian Ocean (Rao and Griffiths, 1998). Off the southwest coast of India, upwelling starts even before the onset of the SW monsoon and continues till it ends in September.

In this study we adopted a synergy of different satellite Earth observation sensor data like ocean colour (SeaWiFs and MODIS), AVHRR and radar altimeter data to make an integrated approach in studying upwelling features in the coastal seas in the Northern Indian Ocean in general and also in the seas around India in particular. It provides information on upwelling of northern Indian Ocean using sea surface temperature (SST) and sea surface height (SSH) anomaly measured from satellites. The upwelling is inferred as low sea surface temperature and low sea surface height variability. The horizontal scales for SST and SSH are not equal, due to SSH being more dominated by the dynamic processes in the ocean than SST, which is more dominated by the smooth atmospheric fields. The Area plot of Ocean color provides the development of chlorophyll maxima in the seas around India in synergy with the upwelling signals in the Indian Ocean. This synergetic approach would provide a tool for understanding and predicting the impacts marine hazards like climate change and other oceanic phenomena like El Nino and Indian Ocean tsunami on the fisheries potential in the seas around India by comparing the chlorophyll anomaly data and SST variability data.

Characteristic features of Rossby and Kelvin wave propagation in the Northern Indian Ocean derived from Satellite Altimetry

Prasanth, D., Research Fellow, NERC
Saji, P.K, Sr. Lecturer, Dept. of Physical Oceanography, Cochin University of Science and Technology, Dr. K. Ajith Joseph, Sr. Scientist, NERC

The characteristics of Rossby and Kelvin waves in the Northern Indian Ocean, was deciphered from ten years (1993-2002) of sea level observations from the TOPEX/POSEIDON satellite altimeter data. Strong semi-annual variability of sea level anomaly was observed along the equator. The characteristic features of the westward propagating Rossby waves along 4°, 6°, 12° and 18°N were analysed and found that it’s speed decreases from 48 cm/sec at 4°N to 6 cm/sec at 18°N. These speeds are comparable to the theoretical phase speed of Rossby waves. Further studies showed that the sea-level anomaly along eastern and western side of the Indian Ocean is out of phase with each other, especially in the equatorial region. By analysing the ten-year SSH anomaly it is found that it’s magnitude changes every year. The major change was noticed in 1998, year after the major El Nino which occurred in the year 1997. Rossby waves in 1998 were seen as highly intensified. This high-intensified signal of the Rossby wave may have it’s root on the signals from the Pacific through the Indonesian throughflow. Another interesting result is that in normal years the Ocean acts like an amplifier for these waves. In the year after the El Nino these amplification capacity of the Ocean ceases (in it’s negative phase). Similarly the studies on the mixed layer depth showed that the MLD also changes in accordance with the Kelvin and Rossby wave propagation in the Indian Ocean, which has a large impact on the heat capacity of the Oceans.
Ocean Tsunami on Chlorophyll
impacts of
of the Equator.

A qualitative study on the
impacts of El Nino and Indian
Ocean Tsunami on Chlorophyll
production in the Eastern Arabian
Sea using Ocean Colour Data

Dr K. Ajith Joseph, Sr. Scientist
Prasanth, D., Research Fellow, NERCI

Eastern Arabian Sea is one of the major
productive regions in the Indian Ocean
as this region often shows maximum
abundance of phytoplankton and
zooplankton. But this region at times
shows decrease in productivity due
to the impacts of oceanic phenomena
like El Nino signals and events like
Tsunami in the Indian Ocean which
regularly occurs in the Pacific. The
present study utilized ocean colour
data from SeaWiFS with the aid of
GIOVANNI (GES-DISC Interactive
Online Visualization AND aAnalysis
Infrastructure) online software to
analyse these impacts for the eastern
Arabian Sea region which is of
interest to Indian marine scientists. We
observed Chlorophyll reduction in
this highly productive regions during
the years after the occurrence of El Nino
in 1997 and also in the year after the
occurrence of Indian Ocean Tsunami
in December 2004. This reduction in
chlorophyll production has directly
affected the fishery potential of the
west coast of India in the year 1998
and 2005 respectively. The approach
for the study was carried out by using
ocean colour data from SeaWiFs for
the year 1998 and 2005 Southwest
monsoon period (June- September)
which was the time of occurrence of
upwelling features and associated
nutrient increase in the surface waters
causing increased primary productivity
in the eastern Arabian Sea. The eight-
year long ocean color data record from
SeaWiFS was used for chlorophyll
concentration anomaly analysis. The
Giovanni climatological anomaly
analysis for chlorophyll data was
performed for the monsoon season
at the study region and compared
the values for that time period to the
SeaWiFS climatological mean data
values and derived the positive and
negative anomalies of chlorophyll
concentration. This was compared
with the chlorophyll anomaly image
of the same study region for a normal
Southwest monsoon time (2004) which
was prior to the occurrence of Tsunami
and observed a positive anomaly
which shows increase in chlorophyll
production during this season due
to algal blooming. The Area plot of
Ocean color provides the development
of chlorophyll maxima in the seas
around India in synergy with the
upwelling signals in the Indian Ocean
in normal years. However during year
after the occurrence of El Nino and
Indian Ocean Tsunami in the Indian
Ocean it is found that chlorophyll
concentration is reduced which in
turn affect the fisheries potential in the
eastern Arabian Sea during
these years (1998 and 2005).
This study identified the fact
that oceanic phenomena (El
Nino) and events (Tsunami)
have negative effect on the
chlorophyll production in the
normally productive regions
of the eastern boundary
currents surrounding the
Oceanic regions in the

Role of meso-scale eddies in the
distribution of Chlorophyll-a in the
seas around southern peninsular
India.

Roshin P. Raj, NANSEN-NERCI
Research Fellow,
Prasanth, D, Research Fellow,
Dr. K. Ajith Joseph, Sr. Scientist, NERCI

In the summer monsoon, chlorophyll-
a concentration (Chl-a) maps derived
from the Seaviewing Wide Field of
view Sensor (SeaWiFS) indicates
phytoplankton bloom around the
southern tip of peninsular India.
Physical processes associated with
the bloom are studied using sea surface
temperature (TMI-SST data) and
gestrophic velocity anomaly calculated
from sea level anomalies (SLA data
merged from TOPEX/POSEIDON
and JASON). From the present study,
it is determined that eddies play a
major role in the distribution of
chlorophyll-a. The flow pattern of
South-West Monsoon Current (SMC)
is greatly influenced by the presence
of meso-scale eddies. Meso-scale eddies
observed in this region are of the order
of 100 km in diameter. Fig. 1a-c shows
respectively the geostrophic velocity
anomaly, chlorophyll-a concentration
and SST during the last week of June
2002. From Fig 1a, it is determined
that 4 eddies are formed in the study
region which controls the λ shaped
spreading of chlorophyll-a. The
SMC flow in between the 4 eddies.
Eddies in the Palk Bay and southern
coast off Sri Lanka causes intense
upwelling. The SST map confirms
upwelling associated with meso-scale
eddies. From Fig 2a-c, we can see an
intensification in the chlorophyll-a
concentration pattern, which is clearly
controlled by the strengthening
and respective positions of the eddies.
Nutrient transport in to the upper
layers caused by coastal upwelling driven
by monsoon winds and eddy induced
upwelling contributed to the high
chlorophyll-a distribution in this region
during summer monsoon. This study is
a novel approach and gives an insight
into the role of meso-scale eddies for
the development of phytoplankton
blooms in the coastal waters of the seas
around India which is of great interest
in locating potential fishing zones and
occurrence and spreading of harmful algae blooms in the Indian waters.

![Image](image1)

**Fig. 1 upper:** Geostrophic velocity anomaly in the seas around S. India during June, 2002. **Lower left:** Chlorophyll-a concentration in the seas around S. India during June, 2002. **Lower right:** SST in the seas around S. India during June, 2002.

![Image](image2)

**Fig. 2 upper:** Geostrophic velocity anomaly vectors showing mesoscale eddies in the seas around S. India during monsoon. **Lower left:** High chlorophyll-a concentration associated with cold core mesoscale eddies. **Lower right:** Low SST showing generation of cold core eddies in the seas around S. India during monsoon.

**The effect of Indonesian Throughflow in the Indian Ocean - A sensitivity study with different Throughflow fluxes in the HYCOM model of the Indian Ocean**

Rahman Mankettikara, Ph.D. student, NERCI-NERSC

Over the past twenty years, there have been lots of efforts to study the Indonesian Throughflow (ITF) as it is a choke point of the global ocean thermohaline circulation. It is the only tropical oceanic pathway exists in the world Oceans connecting the Pacific and Indian oceans. Thus, the ITF has been linked to the regional as well as the global climate. Large scale observational studies reveal significant export of heat and fresh water to the Indian Ocean through the Indonesian seas. The complex geography of the region, with multiple narrow constrictions connecting a series of large, deep basins, leads to a circuitous flow pathway within the Indonesian seas. Enroute the Pacific inflow waters are modified before enter into the Indian Ocean due to mixing, upwelling and air-sea exchanges.

The ITF is maintaining the heat and salt budgets of the Indian and Pacific oceans. Thus, it influences the stratification and the heat content and hence influencing the oceanic and atmospheric circulation. Without the ITF the nature and characteristics of the Indian Ocean and Pacific Ocean would be very different. ITF is studied extensively during past decades using observational and modeling methods. However, the role of ITF in the mean state of the Ocean-Atmosphere is not completely understood yet. The major hindrance to a conclusion on this aspect is lack of sufficient observation on interannual time-scale. For this same reason most of the researches on ITF are based on numerical modeling.

Realizing the significance of the ITF in the regional as well as global climate, efforts were made to understand its effect on the Indian Ocean. The Hybrid Coordinate Ocean Model (HYCOM, Bleck, 2002) setup for the Indian ocean and is run with prescribed throughflow fluxes. The Indonesian Throughflow influences the transport in the Agulhas region and South Equatorial Current. The circulation near the Australia does not affect the variations in the transport. Model results for different months does not show the seasonal variations of the Indonesian Throughflow in the Indian Ocean.

It is proposed to Implement data assimilation for the Indian Ocean model and the in-situ, remotely sensed sea-level anomalies (SLA) and sea-surface temperature data will be assimilated to the model using the Ensemble Kalman Filter (EnKF, Evensen, 2003). The assimilative run will have to be compared with the free running model results to improve the present capability for forecasting the Indian Ocean and to setup a nested forecasting system in a regional sea in the North Indian Ocean.

**Validation of the HYCOM model for the Indian Ocean region and mesoscale ocean studies of the area**

Mary Swapna George, Ph.D student, NERCI-NERSC

As part of the Ph.D, the model (developed at NERSC) has been running for the years 1992-2002 and was validated using published results and WOCE (World Ocean Circulation Experiment) data. The validation was done for the surface currents for the Indian Ocean and for water masses of selected sections. The temperature and salinity structure were compared
Spin-up phase has been upgraded by a more recent one based on ERA40 data, subsequently averaged and corrected. We expect this upgrade will improve the model water mass distribution. Meanwhile other datasets from the Argo, WOCE, and other remote sensing data are being processed for further studies.

Persistent occurrence of high chlorophyll in the Gulf of Khambhat due to cyclonic-anticyclonic eddies in the northeastern Arabian Sea.

Roshin P. Raj, Nansen-Nerci Research Fellow
Tejna, T. Post graduate student in Oceanography, CUSAT
Dr. K. Ajith Joseph, Sr. Scientist, Nerci

In a recent study on the distribution of chlorophyll concentration in the eastern Arabian Sea using Ocean color data it was observed that in all the seasons, the coastal regions of Gujarat show high chlorophyll concentrations especially the Gulf of Kutch and Gulf of Khambhat along the north eastern Arabian Sea which have the highest concentration in almost all the seasons. The reason for this was assumed to be river runoff and low bathymetry in this area which contributed to the increased nutrient inputs into the surface waters. Similarly the winter cooling in the northern Arabian Sea was also contributing to this high chlorophyll presence in this region. But our present study has identified that the major contributing factor for the persistent occurrence of high chlorophyll is due to the cyclonic (Fig. 1 a-c) and anticyclonic (Fig. 2 a-c) eddies in the seas around Gujarat coast. This was derived from the geostrophic velocity calculated from the sea level anomaly data from TOPEX/POSEIDON/JASON merged SLA data comparing with ocean color data from SeaWiFS and TMI for chlorophyll and SST. This study has also helped to have a better understanding of the surface water characteristics and its effect on controlling the algal bloom events in the eastern Arabian Sea. It has conclusively focused on the different approaches to be adopted in understanding the variability of primary production in the eastern Arabian Sea region by analyzing inter seasonal and intra seasonal characteristics of chlorophyll a and SST with respect to generation of mesoscale eddies in the eastern Arabian Sea. The climatological anomaly analysis carried out on chlorophyll concentration in the eastern Arabian Sea has shown the...
comparatively unusual high values in the bloom season. In pre monsoon season, the higher concentrations in the range 7.4–17 mg m$^{-3}$ were seen in the Gujarat coast, with higher concentration in the gulf of Khambath. SST maps show an inverse relation with chlorophyll-a concentration. In the Gujarat coast, the SST was in the range 26–29 $^\circ$C, which is lowest in the coastal regions. In the monsoon season, the chlorophyll concentration all along the western coast of India was high, reaching up to 30 mg m$^{-3}$ and SST also shows an inverse relationship in high concentration areas. In the Gujarat coasts the SST was above 28.5 $^\circ$C, which is an anomalous phenomenon that there is still high concentrations of chlorophyll in this region, or it shows a positive relation ship between chlorophyll and SST in this region in September. In the post monsoon season the chlorophyll concentration higher values were observed in the Gujarat coasts. Open ocean concentrations were still lower than the near shore regions. And SST and chlorophyll-a concentration here also shows an inverse relationship. The interrelationship between two biophysical parameters like chlorophyll a and SST has shown some characteristic relationship as mutually exclusive and mutually dependent in view of different environmental conditions in the marine environment. The role of mesoscale eddies in determining the occurrence and distribution of chlorophyll concentration and phytoplankton blooms due to eddy induced upwelling has to be incorporated in the prediction and forecasting of potential fishing zones in the Arabian Sea rather than relying only on identification of thermal fronts and wind induced upwelling in the seas.

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