Coral reefs of Bahamas, Atlantic Ocean

Ocean's Colour From Space

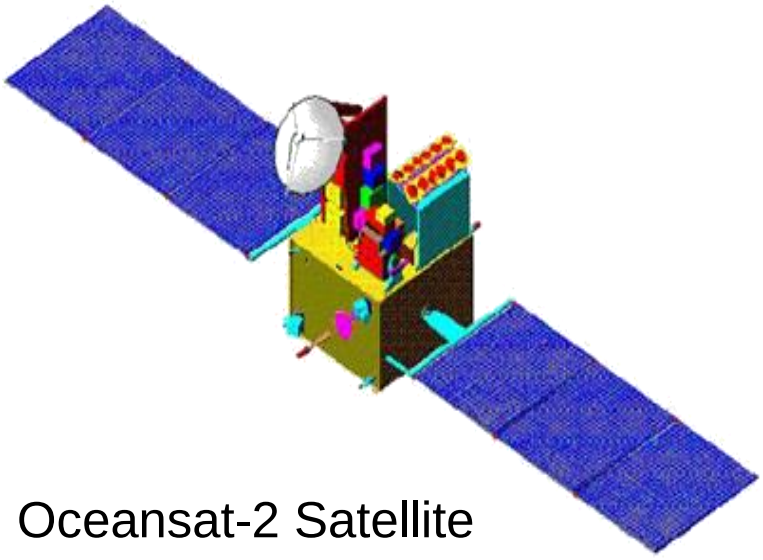
Images from Oceansat OCM sensor

iirs

Ocean's Colour From Space

Images from Oceansat Ocean Colour Monitor (OCM) Sensor

Indian Institute of Remote Sensing
Indian Space Research Organisation
Dehra Dun-248001, India



Oceansat-2 Satellite

Ocean's Colour from Space : Images from Oceansat OCM sensor
2018

Published by

Indian Institute of Remote Sensing (IIRS)
Indian Space Research Organization (ISRO)
Dehra Dun 248001, India

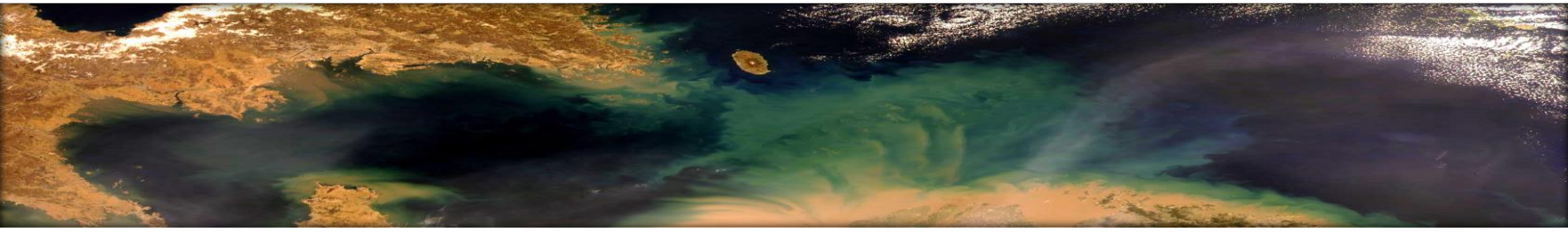
This true colour image of Irrawaddy river delta shows heavy sediment discharge, owing to the four highly turbid rivers, into the sea thereby giving the muddy look.

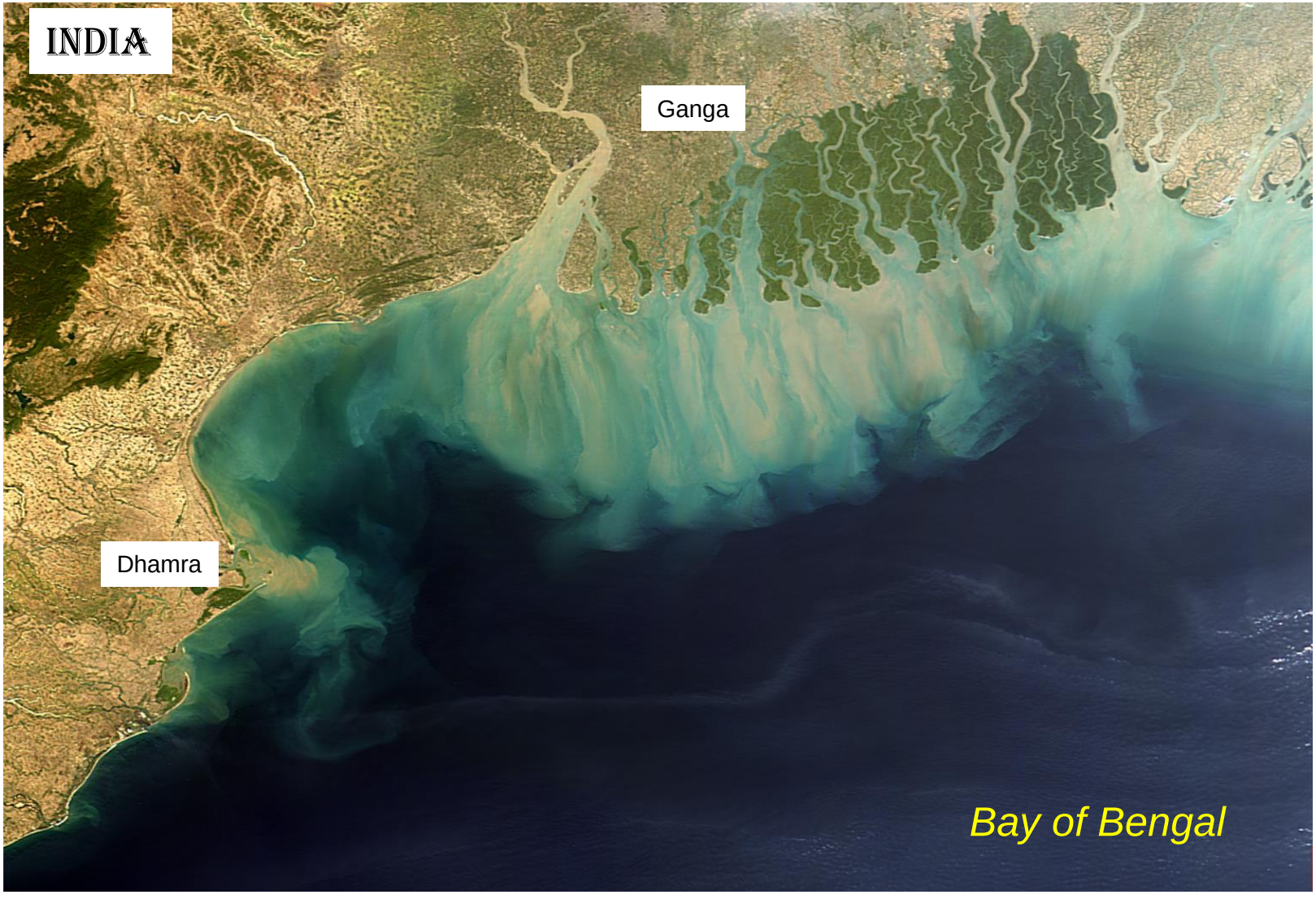
Contributions

Prakash Chauhan[1]
A K Mishra[1]

Rimjhim Bhatnagar Singh[2]
Arvind Sahay[2]
Nivedita Sanwlani[2*]
Mini Raman[2]

1. Indian Institute of Remote Sensing (IIRS), Dehra Dun
2. Space Applications Centre, Ahmedabad
2. Now at* Asian School of Environment Nanyang Technological University, Singapore





OCEANSAT-2 OCM Jan 31, 2018 Natural Colour Composite Ganga Brahmaputra River Delta, Bay of Bengal. Image shows discharge of sediment laden waters from Ganga and Dhamra rivers into Bay of Bengal.

भारतीय अन्तरिक्ष अनुसंधान संगठन
अन्तरिक्ष विभाग
भारत सरकार
अन्तरिक्ष भवन
न्यू बी ई एल रोड, बेंगलूर – 560 231, भारत
दूरभाष : +91-80-2341 5241 / 2217 2333
फैक्स : +91-80-2341 5328

डॉ.कै. शिवन / Dr K. SIVAN
अध्यक्ष / Chairman

Indian Space Research Organisation
Department of Space
Government of India
Antariksh Bhavan
New BEL Road, Bangalore - 560 231, India
Telphone: +91-80-2341 5241 / 2217 2333
Fax : +91-80-2341 5328
e-mail : chairman@isro.gov.in

FOREWORD

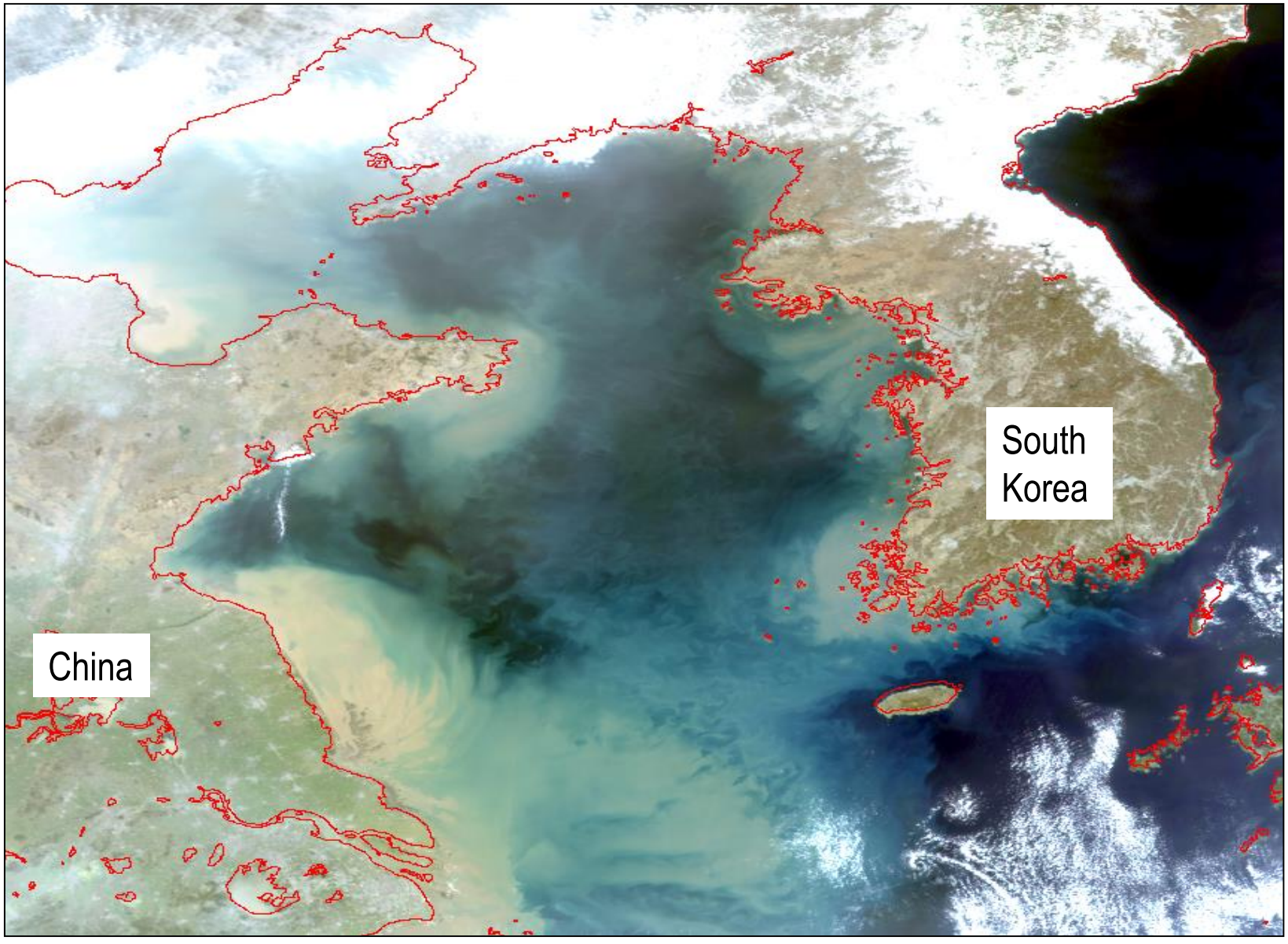
Oceans are the most significant and prominent component of our - Blue Planet. However, this vast portion of the planet is not fully explored and understood. In order to understand the complex nature of the ocean the space platform has been extensively used in the last few decades. In this endeavour ISRO has launched two satellites, the first satellite being Oceansat - 1 (IRS-P4) launched in 1999 and the second being Oceansat -2 launched in 2009 which is operational. In both the satellites, the sensor named - Ocean Colour Monitor (OCM) has provided the data on the colour of the ocean which in turn is useful in deriving the water quality parameters.

Both the missions have provided ample data on phytoplankton content of the ocean, which is not only useful for understanding the ocean environment, but also helpful in identifying productive zones of ocean. The ocean colour data is being used for generation of Potential Fishing Zone (PFZ) advisory. These missions have induced great interest among the students and research community in the country to utilise the satellite data in understanding the dynamic marine environment. ISRO has plans to launch Oceansat-3 also in near future.

At this juncture, it is nice to note that Indian Institute of Remote Sensing (IIRS), Dehra Dun is bringing out the image compilation of bio-geo-chemical diversity of oceans as seen by Oceansat 1 & 2 OCM data in the form of an atlas "Ocean Colour from Space". This atlas highlights the significant observations of ocean around the Indian region as well as around the globe. This atlas will be of great interest to scientific community and I acknowledge the efforts in bringing out this atlas and congratulate all those who have contributed to this compilation.

Bangalore
Nov 7, 2018

(कै. शिवन / K. Sivan)



OCEANSAT-2 OCM natural colour image over Bohai Sea and Yellow Sea between northeastern China and the Korean Peninsula showing highly turbid water. This region is shallow and receives large amount of sediment from the Yellow (Huang He), Yalu, and Yangtze Rivers.

Dr Prakash Chauhan
Director, IIRS

PREFACE

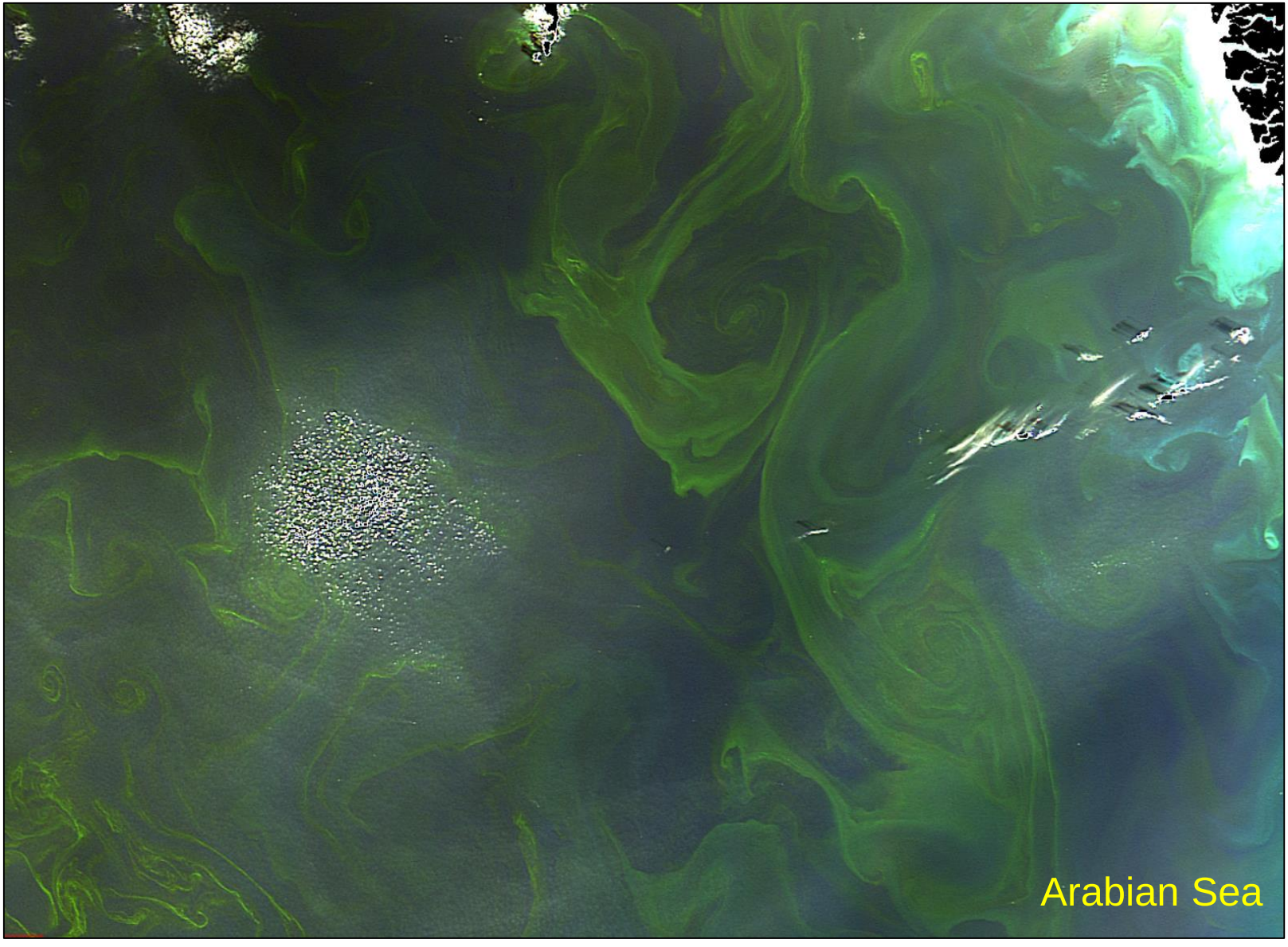
The oceans of the world play a key role in modulating various climatic processes of the Earth system. The world ocean absorbs about 97% of the solar radiation incident on it and provides 85% of the water vapour in the atmosphere. It exchanges, absorbs and emits a host of radiatively important gases. It is also a major natural source of atmospheric aerosols. Spatial and temporal dynamics of its surface properties allows great scope for feedbacks between the ocean and atmosphere. Ocean biota, in particular phytoplankton plays a fundamental role in regulating the Earth's energy balance. Ocean-colour refers to the spectral behavior of the ocean reflectance; i.e., the ratio of solar radiation exiting the sea to the radiation entering it through the surface. Changes in ocean-colour are largely governed by the oceanic chlorophyll concentration, and therefore, this concentration is derivable from inversion of the reflectance spectrum; in particular, when this spectrum is recorded from space. Phytoplankton chlorophyll can be used as an index of the algal biomass.

Satellite based ocean-colour remote sensing has emerged as one of the most important tool for the monitoring the oceanic phytoplankton over last four decades. Indian Space Research Organization (ISRO) has launched two dedicated satellites OCEANSAT-1 and OCEANSAT-2 for studying ocean biological ecosystems. Both the missions have provided ample data on phytoplankton content of the ocean. These data sets are being used for generation of Potential Fishing Zone (PFZ) advisory. OCEANSAT missions have drawn attention of students and research community in the country to utilise the ocean colour data to understand the dynamic marine environment.

Indian Institute of Remote Sensing (IIRS), Dehra Dun is bringing out the compilation of set of images from Oceansat 1 & 2 data in the form of an atlas - Ocean Colour from Space to show case different oceanic phenomenon . I hope this will be of use to understand various oceanic processes.

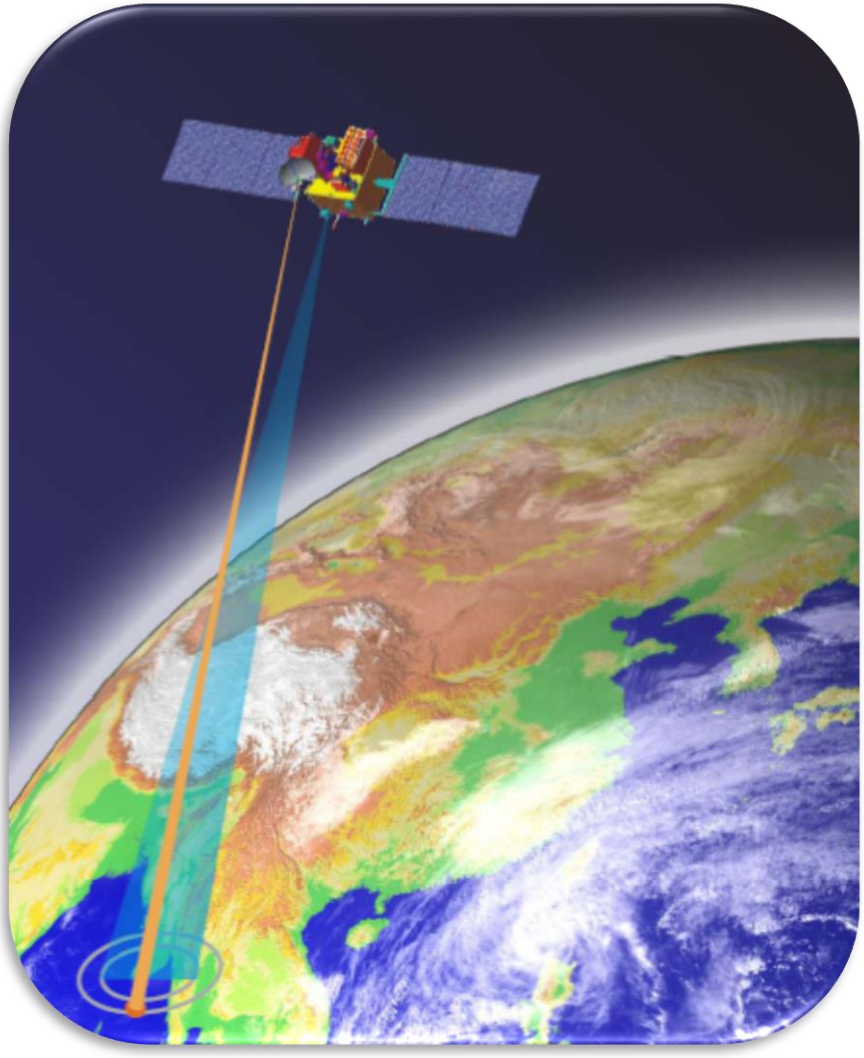
Dehra Dun
Nov 7, 2018

(Prakash Chauhan)



Forest of the Sea : Massive Outbreak of Noctiluca algal blooms in green colour in the Arabian Sea as captured by OCEANSAT-2 OCM on Feb 8, 2018

About ‘Ocean’s Colour From Space’

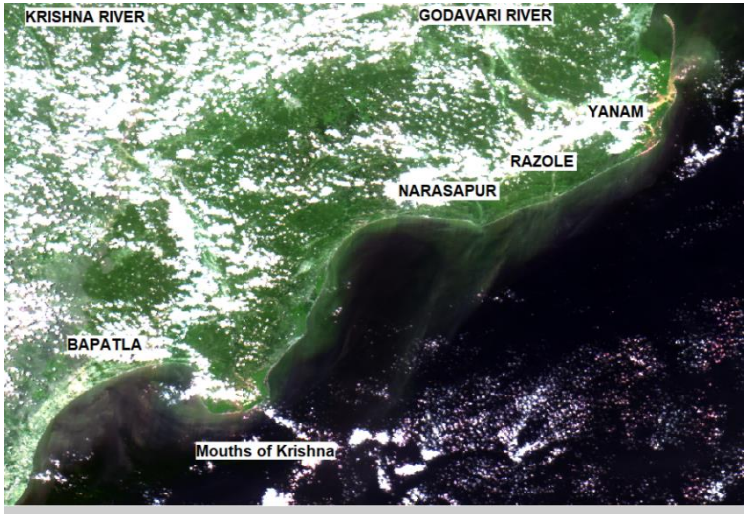


Indian Space program has laid significant importance to understand oceans around the world using Earth Observation satellites. OCEANSAT-1 spacecraft launched in 1999 paved the way to study biological oceanography through a highly advanced sensor named as Ocean Colour Monitor (OCM). Images beamed by OCM sensor provided unprecedented view of oceanic biomass in terms of Chlorophyll concentration. The data from this sensor was used for assessing marine resources through operational activities like Potential Fishing Zone (PFZ), algal bloom detection, suspended sediment dynamics etc. Later to provide continuity to OCEANSAT-1 OCM a modified OCM-2 sensor was launched in 2009. Both these sensors have provided thousands of images covering global oceans about the unique marine and coastal eco-systems along with applications to land and atmospheric studies.

This compilation aims to showcase some of these images captured by OCEANSAT-1 and OCEANSAT-2 OCM sensors.

Suspended Sediment in the coastal waters as seen by Oceansat-2

OCEANSAT-2 OCM Jan 31, 2018

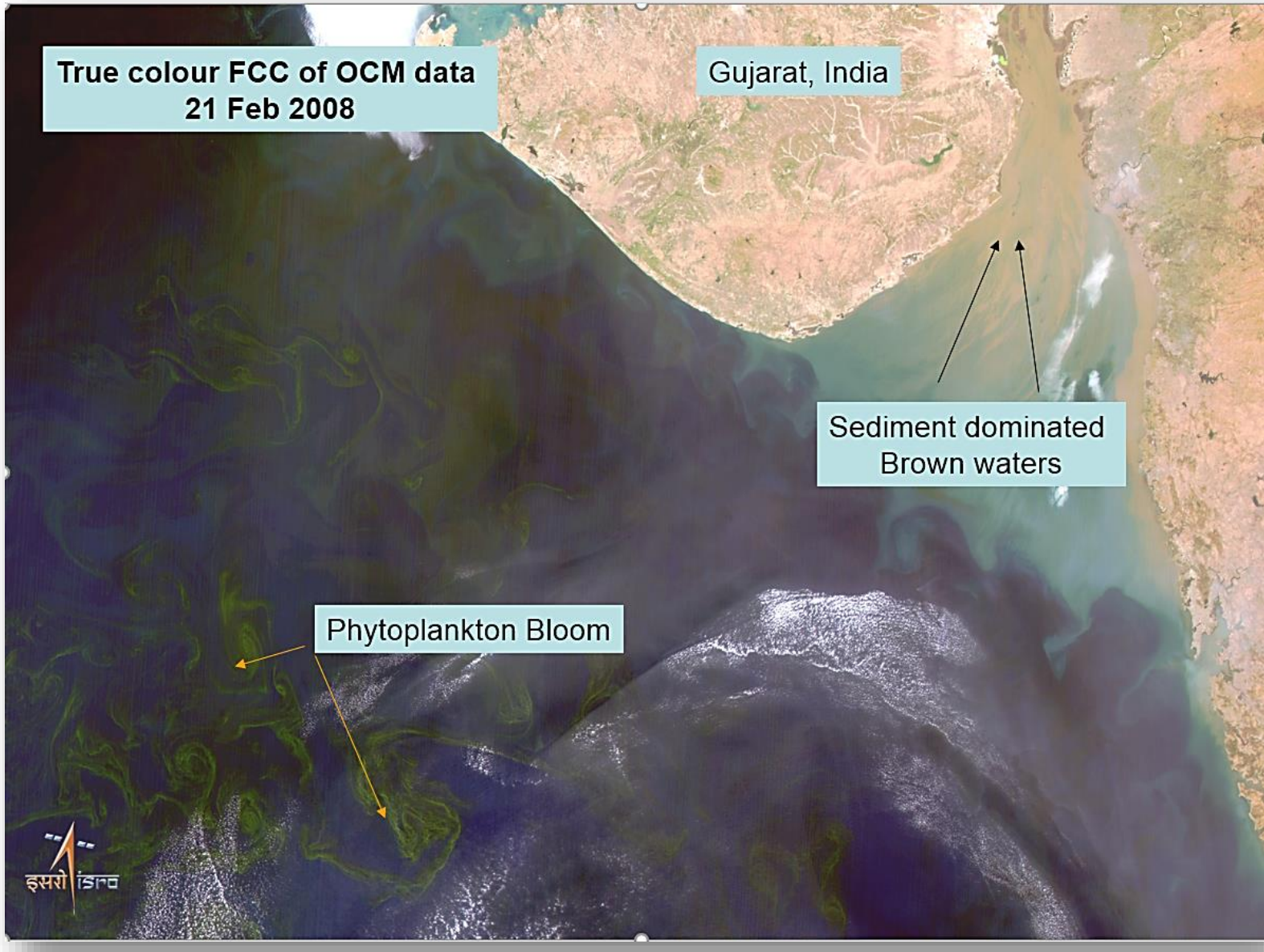


OCEANSAT-2 OCM OCT 02, 2018

The suspended sediment discharged by the rivers to the coastal waters are modulated by many factors. Few of the important factors responsible for increased suspended sediment load in the coastal area are heavy rainfall, deforestation and urbanisation. Agriculture practice without using precise techniques, unplanned land use, such as establishment of industrial facilities or uncontrolled urban development are fundamental factors of soil erosion.

In the climatic change scenario, the Earth will experience intense cyclonic storms and heavy precipitation. As a result, there is a possibility of increase of suspended sediment load in the coastal waters. The increase in suspended load in the coastal waters not only effects the coastal ecology, but also can serve as an indicator for assessment of many environmental and climatological consequences. River-dominated coastal waters along with the adjacent continental shelf are crucial marine sectors where the exchange of water and chemical constituents take place with open oceans and play a significant role in global biogeochemical cycles. Therefore, monitoring of suspended sediment in the coastal waters particularly near estuarine region are quite important.

Table of Contents

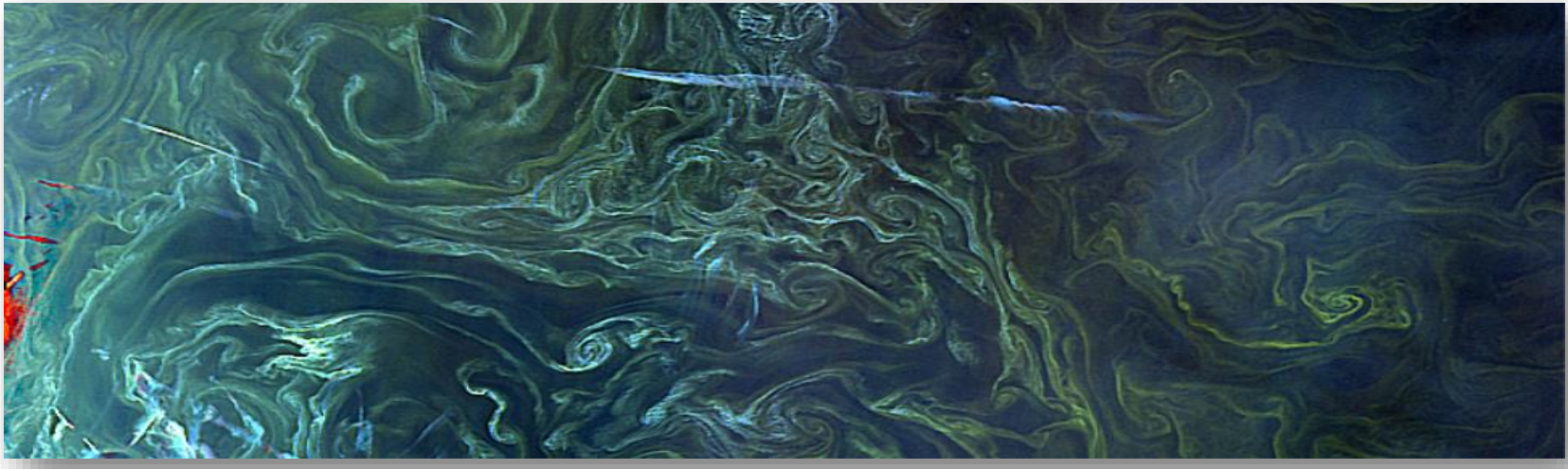


Colour of the coastal waters around Gujarat coast on February 21, 2008. The Gulf of Khambat is dominated by sediments and appears muddy brown as compared to green patches of algal bloom (*Noctiluca Scintillans*) and deep blue open oceans waters

Background - Ocean Colour Monitor onboard OCEANSAT-1 & 2

Indian Space Research Organization (ISRO) has a committed ocean colour program and has launched two dedicated ocean colour sensors onboard OCEANSAT-1 & 2 satellites. The Ocean Colour Monitor (OCM) instrument has been designed to measure subtle variations of ocean colour in-terms of the spectral variation of water leaving radiance that can be related to concentration of phytoplankton pigments, suspended matter and coloured dissolved organic matter in coastal and oceanic waters, and the characterization of atmospheric aerosols.

OCEANSAT-1 was launched in May 1999 and has been followed by OCEANSAT-2 in September 2009, the second satellite in ocean series of ISRO. Ocean Colour Monitor observes Earth surface in eight spectral bands i.e. 412, 443, 490, 510, 555, 670, 765 and 865 nm. It has a spatial resolution of 360 m and a wide swath of 1420 km. OCEANSAT-2 OCM is mainly designed to provide continuity to the OCEANSAT-1 OCM instrument and is almost identical to OCEANSAT-1 OCM, however central wavelength of two spectral bands i.e. band 6 and 7 were shifted. The spectral band 6, which was located at 670 nm in OCEANSAT-1 OCM has now been shifted to 620 nm for improved quantification of suspended sediments. The spectral band at 620 nm is also useful for substrate mapping of optically shallow coral reefs and other benthic ecosystems. The spectral band 7, which was located at 765nm in OCEANSAT-1 OCM has been shifted to 740 nm to avoid oxygen absorption. OCM-2 maps ocean colour in two spatial resolutions: Local Area Coverage (LAC) of 360 m and Global Area Coverage (GAC) of 1 km.



The Oceanic & Aquatic Biosphere
Oceanic Primary Producer

Aquatic biomes are the diverse and dynamic ecosystems which cover major part of the Earth. They contain fresh water (salt content <1%) and salt water (salt content ~>3%) ecosystems. Latitudinal variation within them is less.

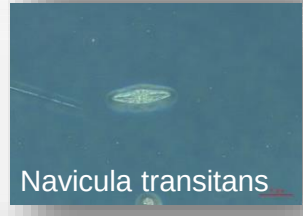
Based on water depth and distance from shore, water bodies are divided into various zones, the top being **photic zone**. In this zone, *light is available for photosynthesis*. Phytoplanktons, cyanobacteria, macroalgae and a few aquatic plants exist in this zone. Then comes the **aphotic zone**-*zone where light is insufficient to support life* and finally **benthic *zone***-*the bottom, comprising mainly of sand, rock etc. and a few organisms* that feed on waste matter of photic zone.

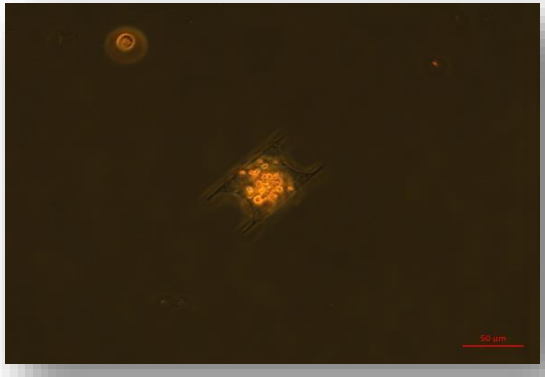
Phytoplankton form the base of food chains in the aquatic ecosystem and primarily thrive in photic zone. Photoactive pigments like Chlorophyll-a, present in phytoplankton, cause distinct changes in the colour of water by absorbing and scattering the light incident on water. It also tells about the trophic status of water.

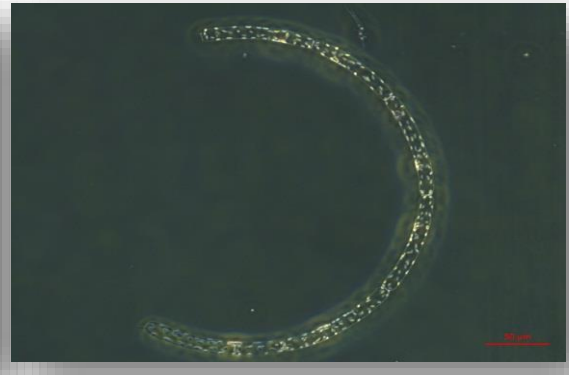

Dinophysis acuminata

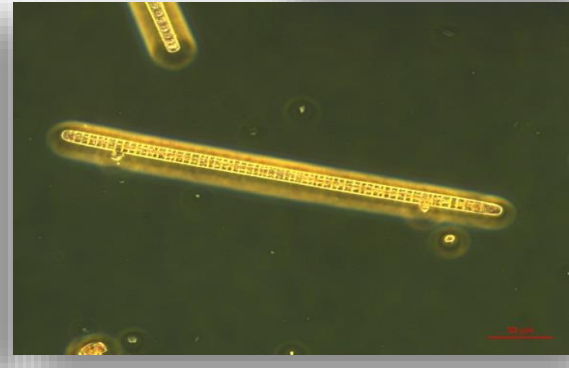

Corethron criophilum


Ditylum brightwellii


Navicula transitans

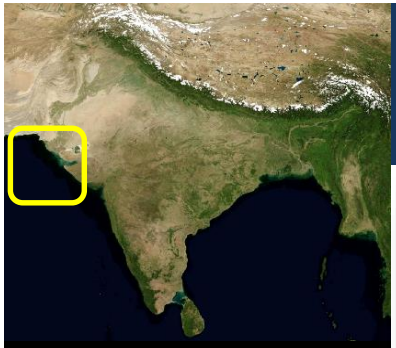






The Oceanic & Aquatic Biosphere

Oceanic Primary Producers

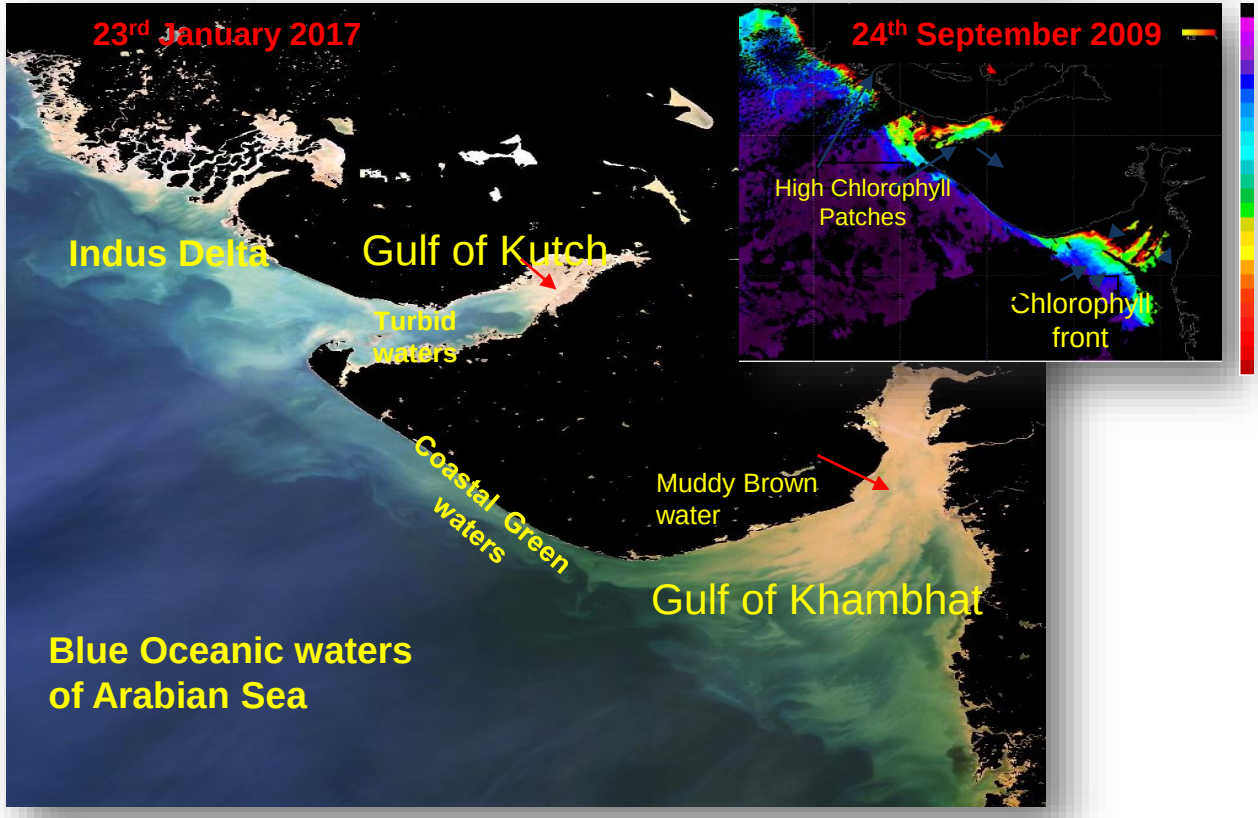


Gulf of Kutch

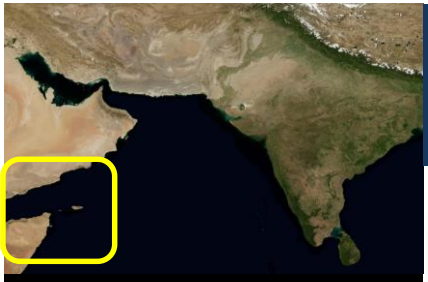
is an inlet of Arabian sea along the west coast. It witnesses extremely high tides. It is the largest coastal habitat in the west coast of India.

Gulf of Khambhat

is a shallow and complex natural basin formed by south to north penetration of Arabian Sea and is intercepted by many inlets of sea and creeks. Every moment, it witnesses huge load of sediments and tremendous amounts of domestic and industrial discharge. The area is rich in biodiversity and has many fishing grounds.



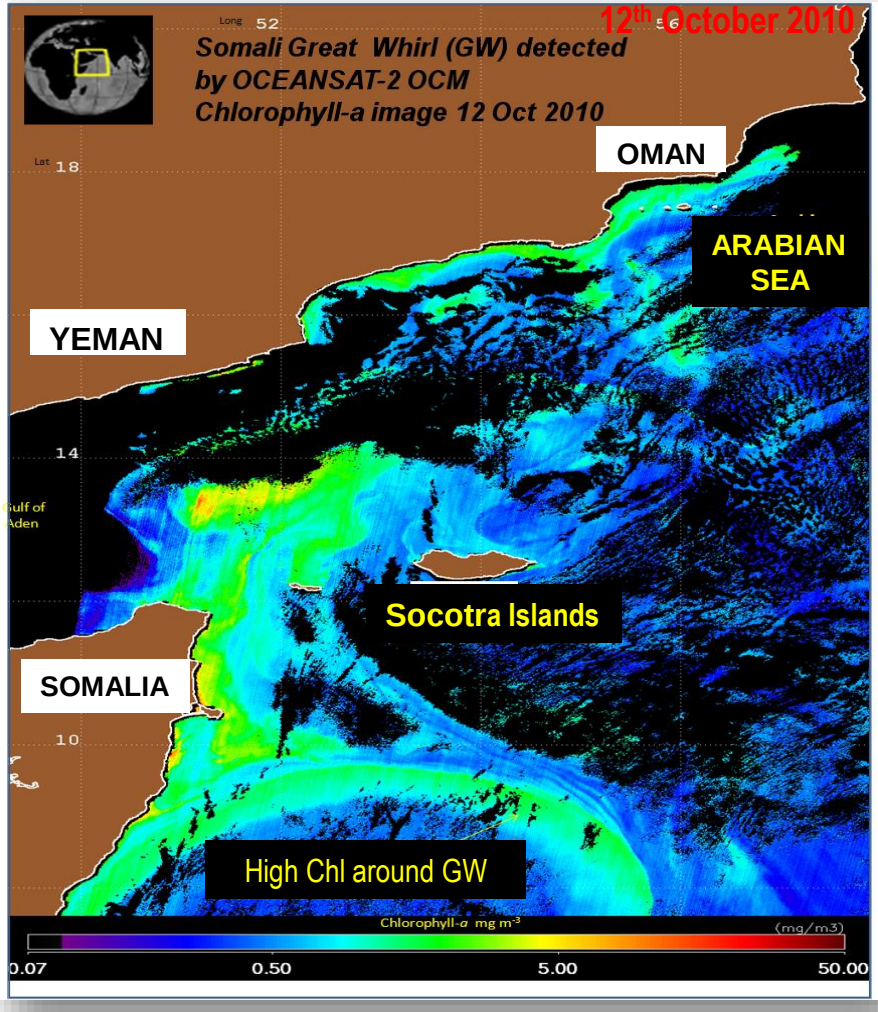
Gulf of Khambhat shows a mix of brown muddy water (as an outcome of huge sediments, often the top fertile soil, carried away from the land by the rivers) and greenish blue water (as an outcome of phytoplankton communities thriving on account of the discharged sediments from the ground). The algal species present here act as fodder for the fishes, thereby making this region a rich fishing ground. The picture in the inset shows colour coded phytoplankton patches and the fronts-the ecological boundaries defining the presence of phytoplankton assemblages and associated group of fishes.



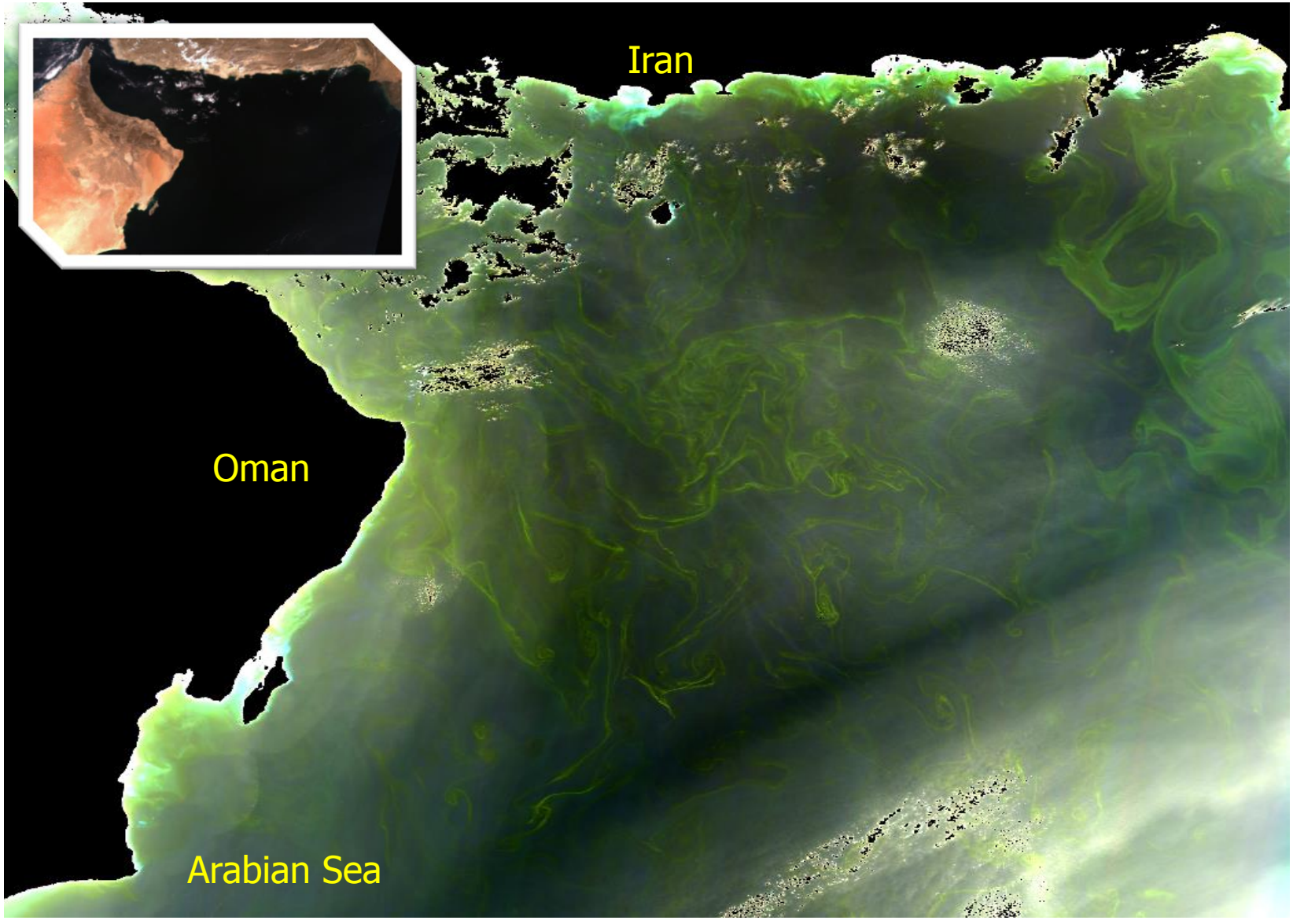
The Oceanic & Aquatic Biosphere

Phytoplankton distribution

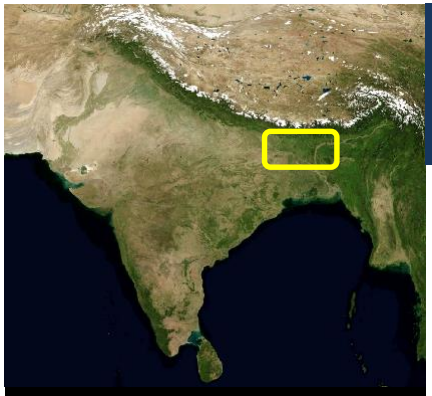
The Great Whirl is a mesoscale feature (~450 km) associated with high chlorophyll concentration along its periphery.



This chlorophyll-a image clearly shows the Great Whirl off the Somali coast. This circulation is caused by the north easterly acceleration of the Somali current through the Socotra passage around Socotra Islands. Such features are commonly seen in ocean-colour data during the transition period of the southwest to northeast monsoon in this region.



Algal blooms (*Noctiluca*) in green colour covering entire in the North Arabian Sea as captured by OCEANSAT-2 OCM on Feb 8, 2018. The green colour is indicative of high growth of marine phytoplankton.

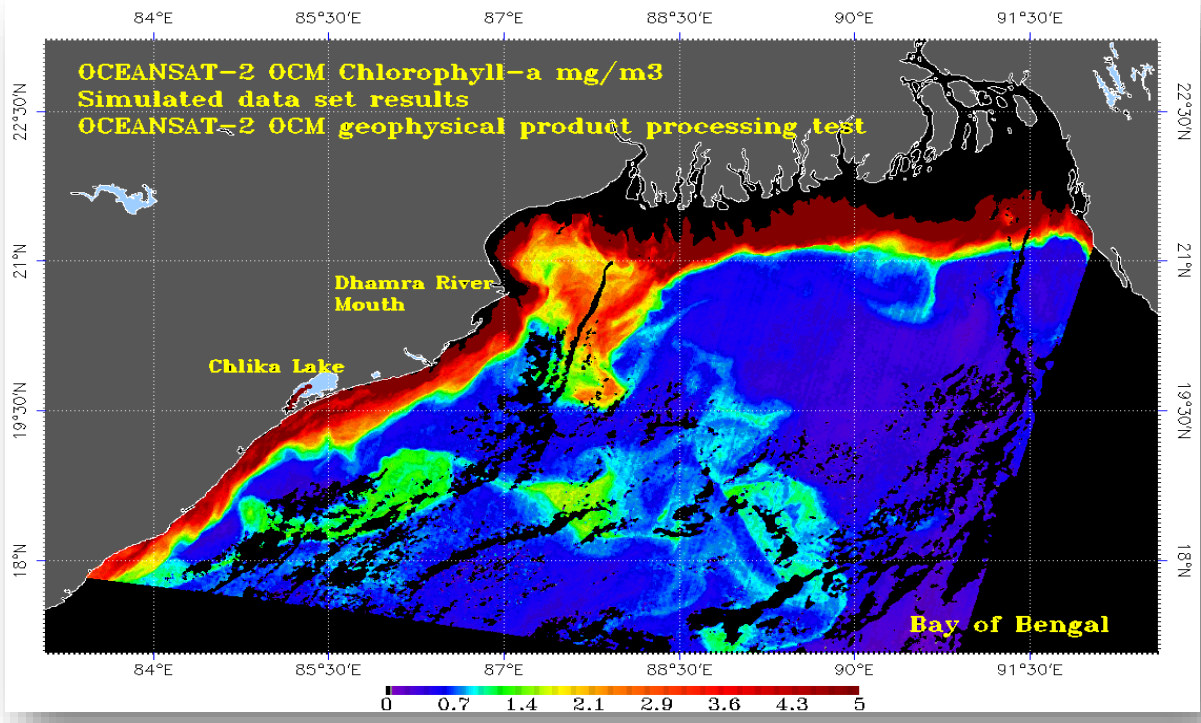


The Oceanic & Aquatic Biosphere

Oceanic Primary Producers

Off Sundarbans water

Mainly comprise of the active delta regions formed by river Ganges, Brahmaputra and Meghna, opening into Bay-of-Bengal. The region is immensely fertile owing to the nutritionally rich sediment deposition by the three rivers. The estuarine area also experiences huge, nutritionally rich sediment load, thereby leading to ecological richness and diversity in these waters.



This chlorophyll-a image from OCM-2 of Off Sundarbans water having mangrove estuaries along-side the grand delta of river Ganges, Brahmaputra and Meghna in the North and river Dhamra in the west show large phytoplankton concentration. High particulate organic material (POM) in these regions lead to phytoplankton succession as seen by brown layer alongside the estuaries. As the nutrient rich water diffuses with the open ocean, the phytoplankton concentation get sparser. Due to the unique hydrography of the region, the currents lead to the dispersal of the phytoplankton, which can be seen in the form of scattered green patches.

The Oceanic & Aquatic Biosphere
Phytoplankton Algal Blooms

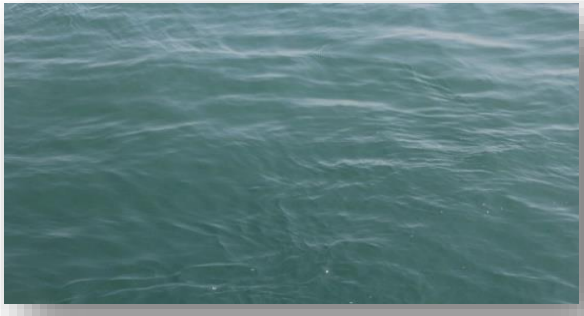
Under certain environmental conditions, phytoplankton species grow unabated at a fast pace in fresh or sea water ecosystems. Such conditions are called algal blooms. High concentrations of phytoplanktons in the water impart green, greenish-blue, brown and even red colour to the water depending upon the type of phytoplankton bloom.

Blooms are temporary events which vanish on their own when the favorable conditions pass. Favorable conditions may include sudden availability of Nitrogen and Phosphorous on which they thrive.

Blooms can affect the environment in several ways. If the favorable conditions stay longer, blooms block the sunlight and depletes the dissolved oxygen in the water thereby hampering the life within the water. Some of the blooms release toxins in the water and are then called-'Harmful algal blooms'.


Trichodesmium erythreum bloom
(Arabain Sea)


Noctiluca scintillans

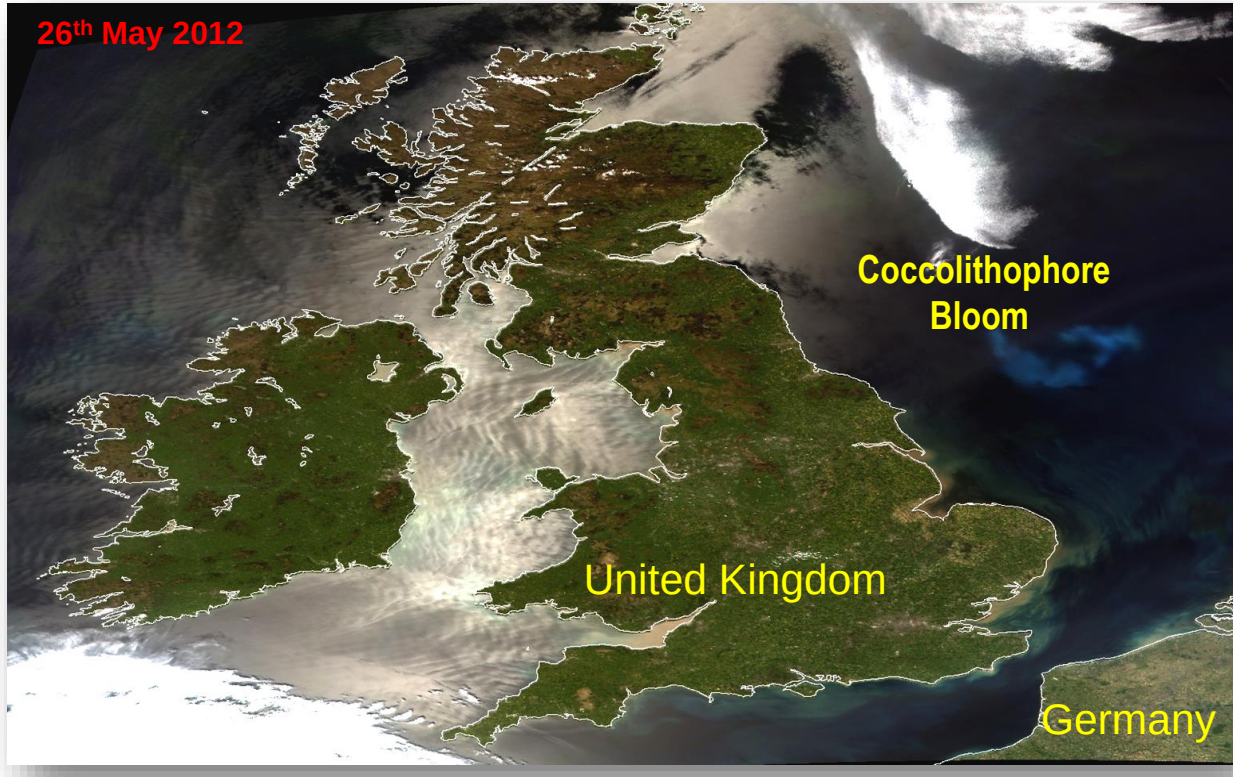


The North Sea

Is a marginal sea of Atlantic ocean. It is an abode of trade and tourism, which has eventually lead to the decline in the ecological conditions.

The Oceanic & Aquatic Biosphere

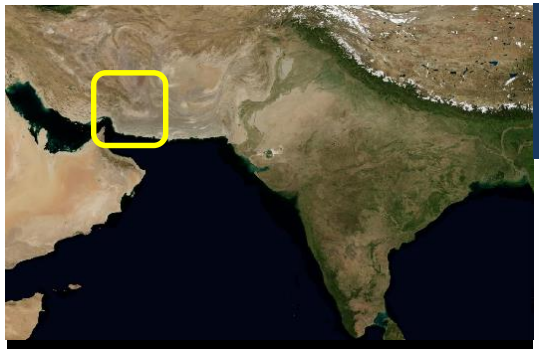
Phytoplankton Algal Blooms



Cocolithophore blooms, captured by Oceansat-2, typically originate in waters of low nutrient supply and mild temperature where other phytoplanktons find it hard to survive. The calcium rich cocoliths impart the milky white appearance to the water thereby making them easy to spot in the satellite imageries.

The Oceanic & Aquatic Biosphere

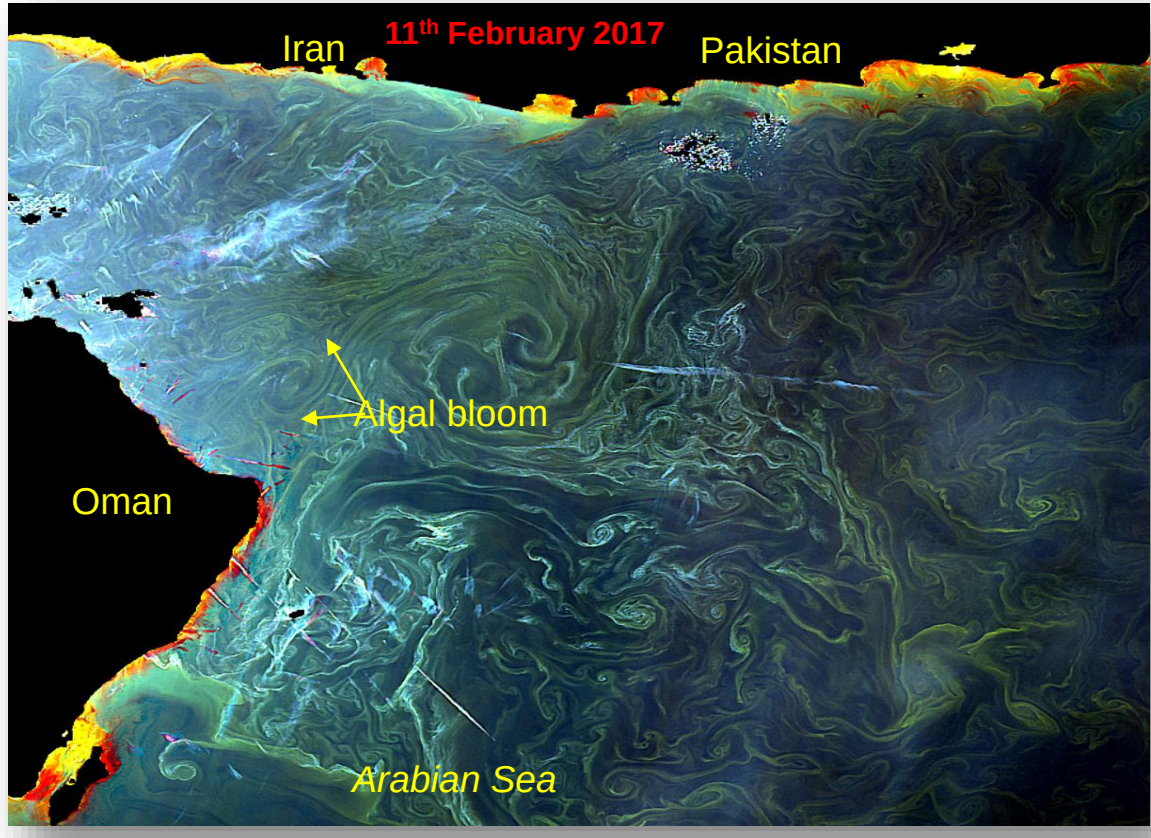
Phytoplankton Algal Blooms



Algal Bloom, Gulf of Oman

Such massive and murkier blooms are common over the past few years as a consequence of climate change.

These blooms displace the zooplankton thereby disturbing the marine food chain and threatening the marine environment.

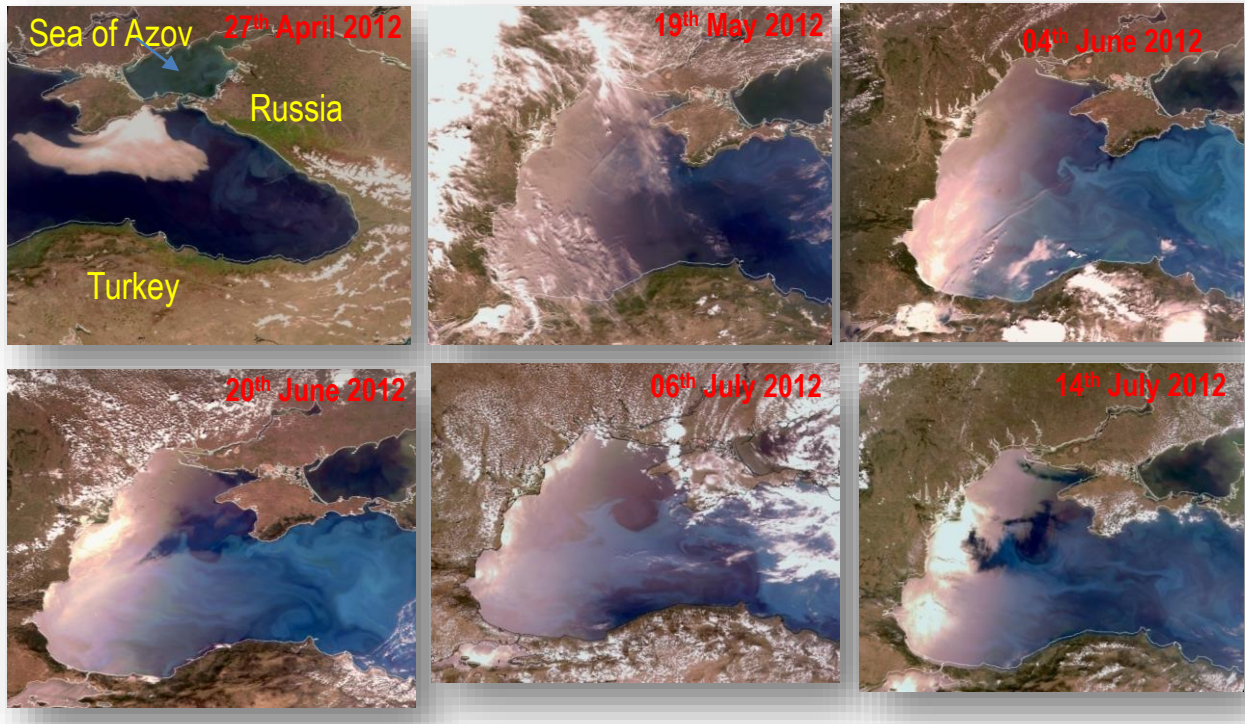


Massive Outbreak of algal blooms (*Noctiluca Scintillans*) in the Arabian Sea as captured by OCM - 2 on Feb 11, 2017. Apart from the density of phytoplankton, the swirls also indicate the dense eddies and currents present within this part of the Arabian Sea.

The Oceanic & Aquatic Biosphere
Phytoplankton Algal Blooms

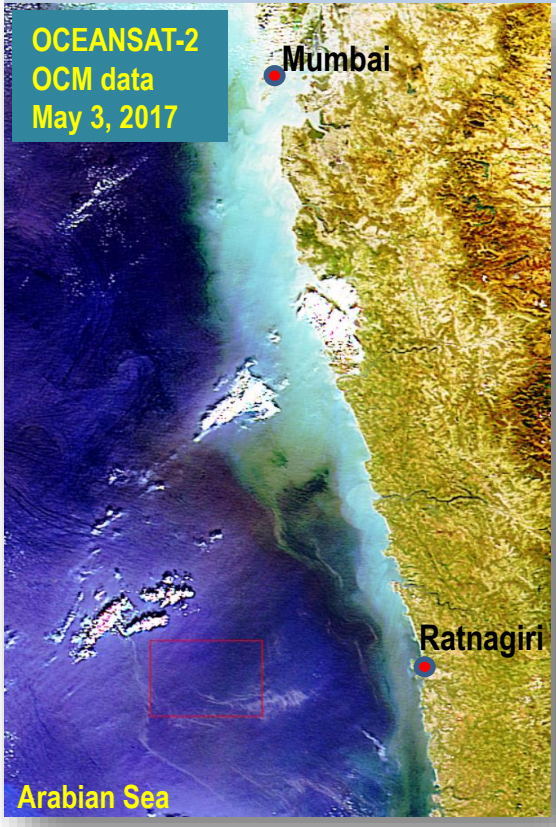
The Black Sea

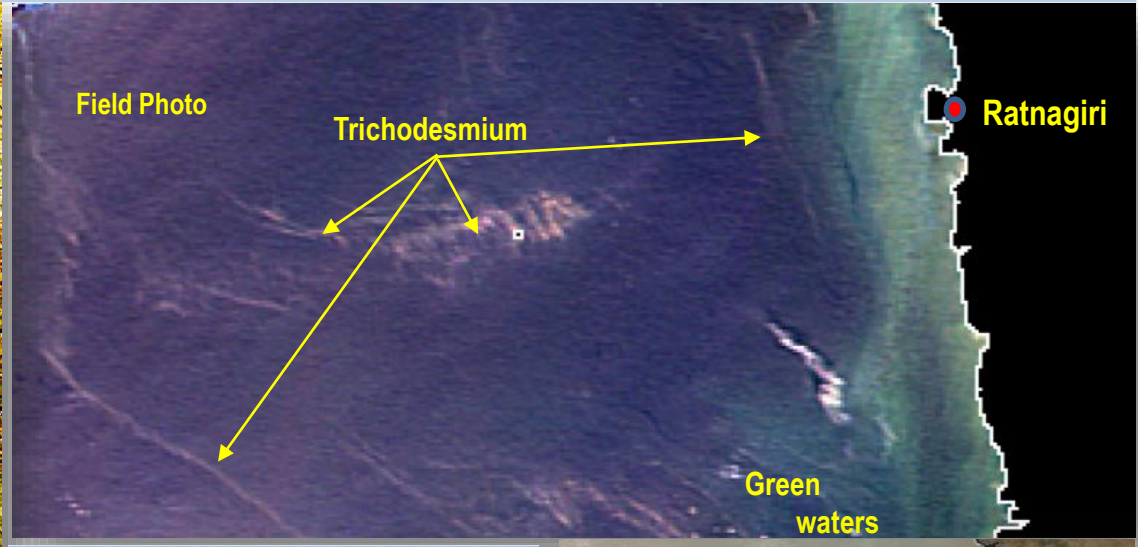
Is the marginal sea between Europe and Western Asia. Many rivers flow into it, important being Danube and Dnieper. Apart from sediments, these rivers dump huge loads of domestic wastes rich in nutrients which Phytoplanktons consume and then multiply. The water layer beneath is highly anoxic while the top layer supports wide range of marine life. The sea witnesses blooms on routine basis.

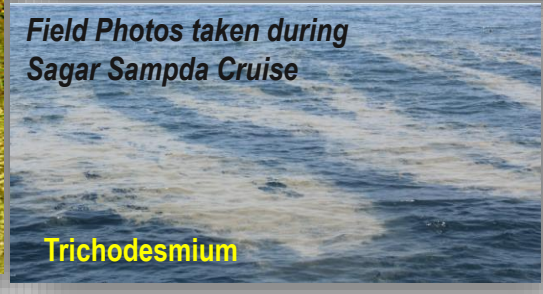


This time series images of OCM-2 reveal several hues of water as an outcome of phytoplankton bloom corresponding to the favourable light and temperature conditions when growth rate of phytoplankton intensifies. The Phytoplankton blooms are visible as brown to blue to turquoise streams and swirls. The associated phytoplanktons here include cocolithophore, cyanobacteria, diatoms and dinoflagellates.

Trichodesmium Bloom detection using OCEANSAT-2 OCM data on May 3, 2017 Off Ratnagiri coast, Maharashtra, India







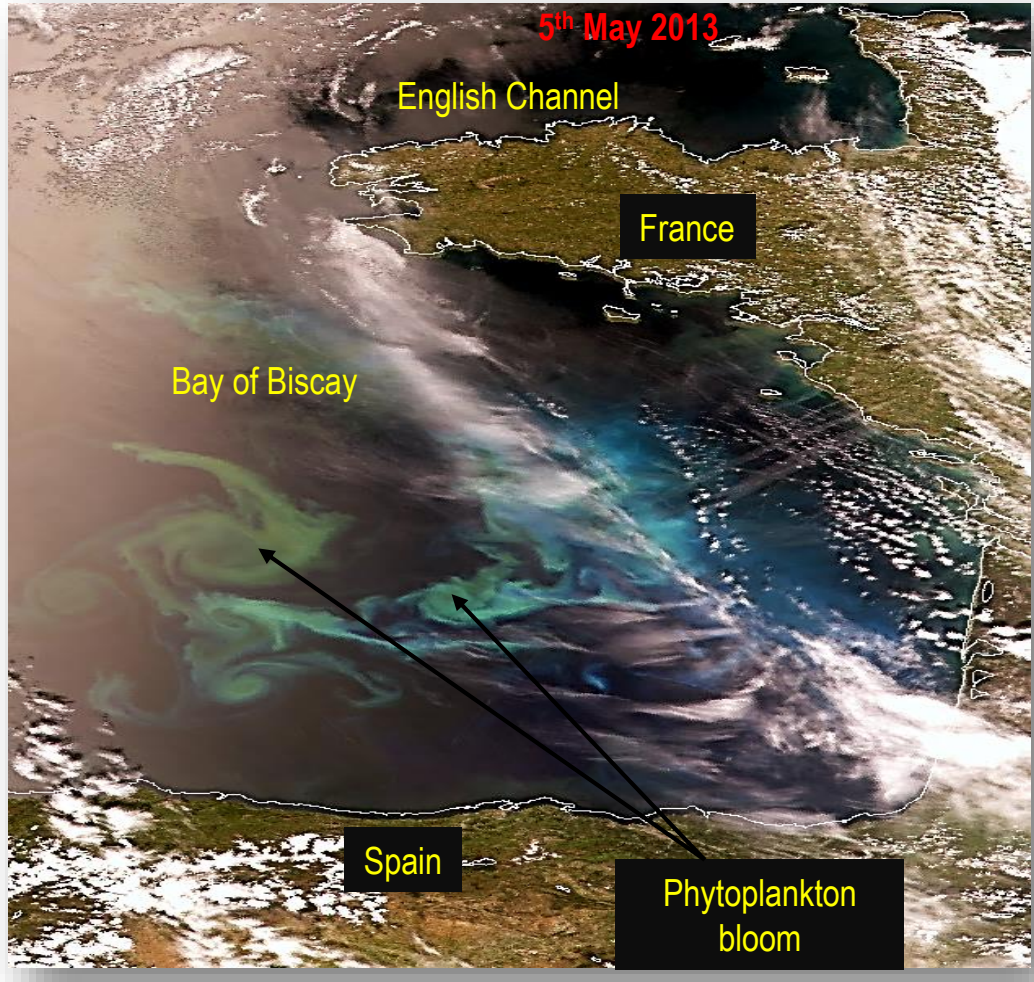
Trichodesmium spp. is nitrogen fixing marine blue-green algae commonly found in tropical oceans. They form massive blooms during summer period, when surface waters are warm and devoid of nitrate. These blooms are important for nitrogen bio-geo-chemistry of oceans.

The Oceanic & Aquatic Biosphere
Phytoplankton Algal Blooms

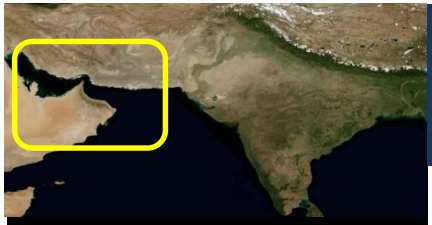
Bay of Biscay

Is a gulf in the Celtic sea. It experiences the fiercest weather conditions in the Atlantic ocean especially in winters. During summers, fog triangle engulfs a large portion of the bay.

Phytoplankton blooms generally occur in this part of the year when cold but nutrient rich waters get summer time temperature and optimum light. The milky white patches are known as Cocolithophore blooms.

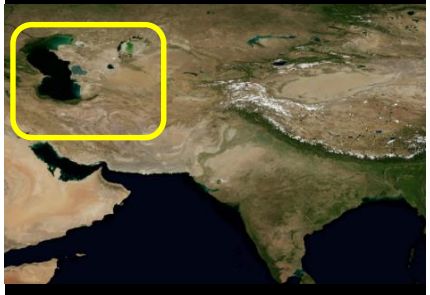


The Oceanic & Aquatic Biosphere
Phytoplankton Algal Blooms



Gulf of Oman

is a strait that connects strait of Hurmuz to the Persian gulf. It witnesses phytoplankton blooms on frequent basis.

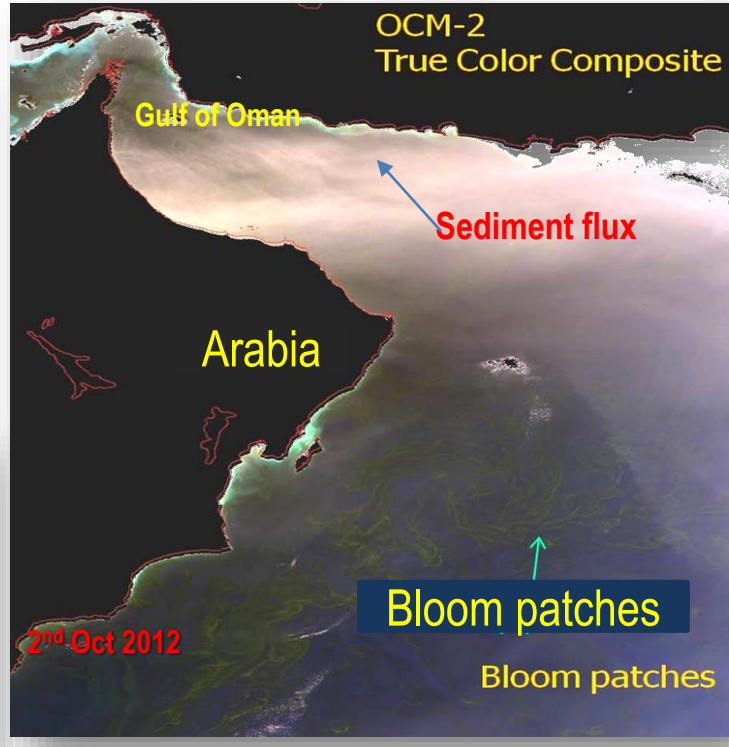


Caspian Sea

is the largest inland enclosed waterbody on Earth, bound between Europe and Asia. It gets discharge from Volga and Ural rivers but has no outflow point. It has characteristics similar to both sea and the lake.

This image of Caspian sea is a wonderful example showing shallow water, deep water (black colour), muddy brown water (sediment rich) as well as phytoplankton affected green waters, all at one place.

Caspian Sea



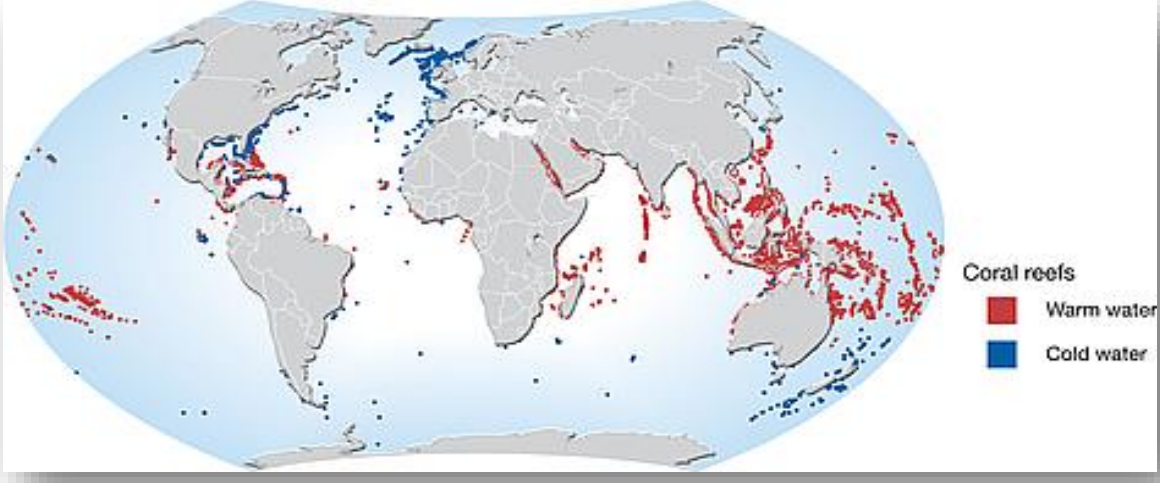
True colour composite of Gulf of Oman shows sediment flux mixing with sea water. The area nearing Gulf of Oman experiences temperature gradient in the winter monsoons leading to phytoplankton bloom patches, as shown in the image.

The Oceanic & Aquatic Biosphere
Coral Reefs

Coral Reefs are diverse under water ecosystems that are held together by the calcium carbonate structures secreted by the corals. Although they comprise of not more than 1% of the entire marine environment, they provide food and habitat to more than 25% of all oceanic species. Additionally, they act as physical barrier to storms, hurricanes and typhoons.

In recent times, coral reefs are at threat mainly due to rising ocean temperatures and ocean acidification. High temperatures lead to the dangerous outcome of 'coral bleaching'.

Corals are dying and hence need to be routinely monitored.



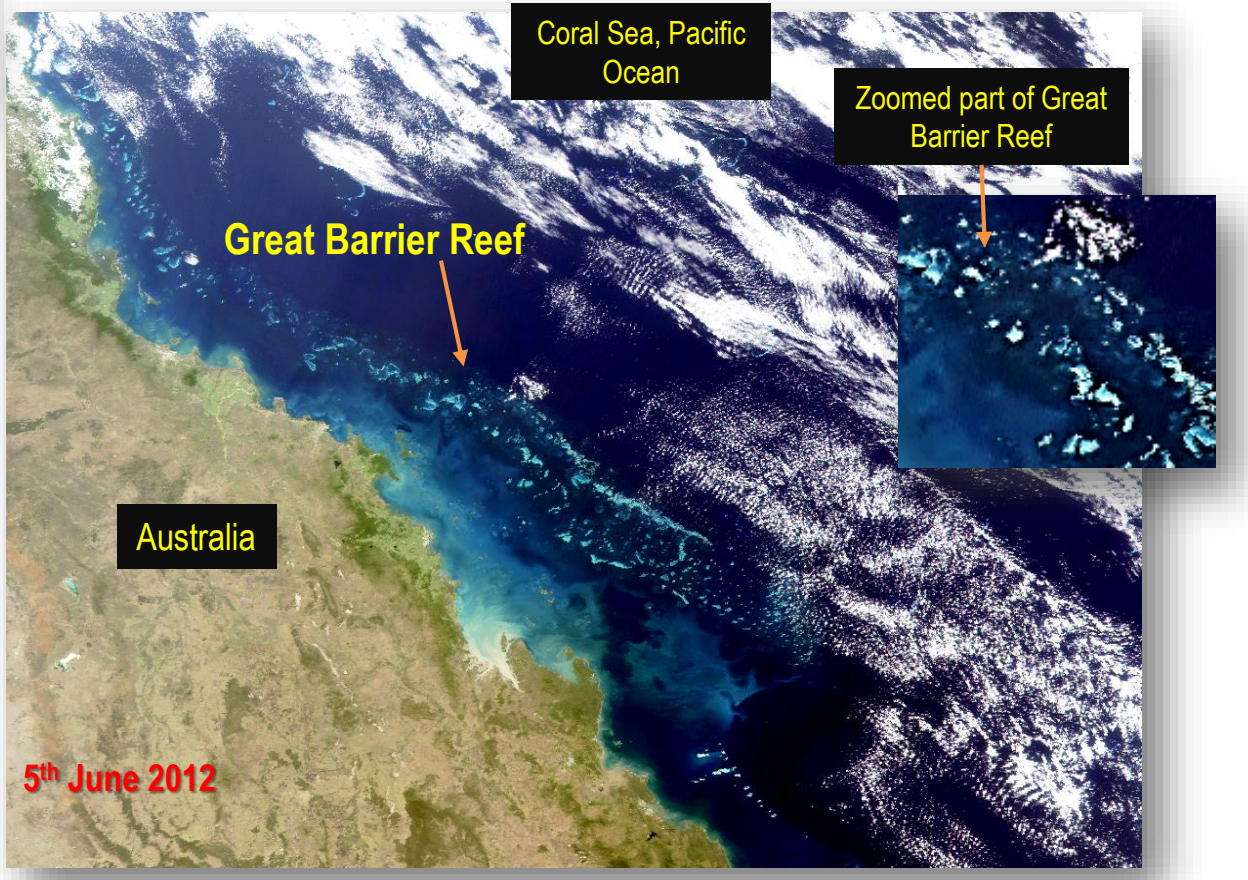
The Oceanic & Aquatic Biosphere

Coral Reefs

The Great Barrier Reef

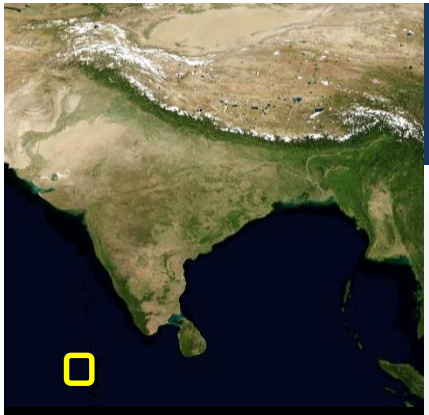
Is the world's largest coral reef system, which can be seen from outer space. It was declared as world heritage site in 1981. The reef is home to large number of species, some endangered.

Over the years, climate change and pollution has adversely affected the coral reefs and has posed a threat to the marine life here.



In this image of OCM-2, the Great Barrier Reef is seen as huge boundary separating the coastal areas with the Coral Sea.

The Oceanic & Aquatic Biosphere
Coral Reefs



Maldives Island

Maldives is the smallest and most dispersed Asian country consisting of 26 atolls. Together, the Maldives atolls comprise of about 187 coral species. These are homes to a wide range of marine life starting from phytoplankton to whales and sharks. All lands above surface in Maldives are coralline in nature.

This image looks like a pearl necklace and so is the name-'mala' means garland in the name Maldives.

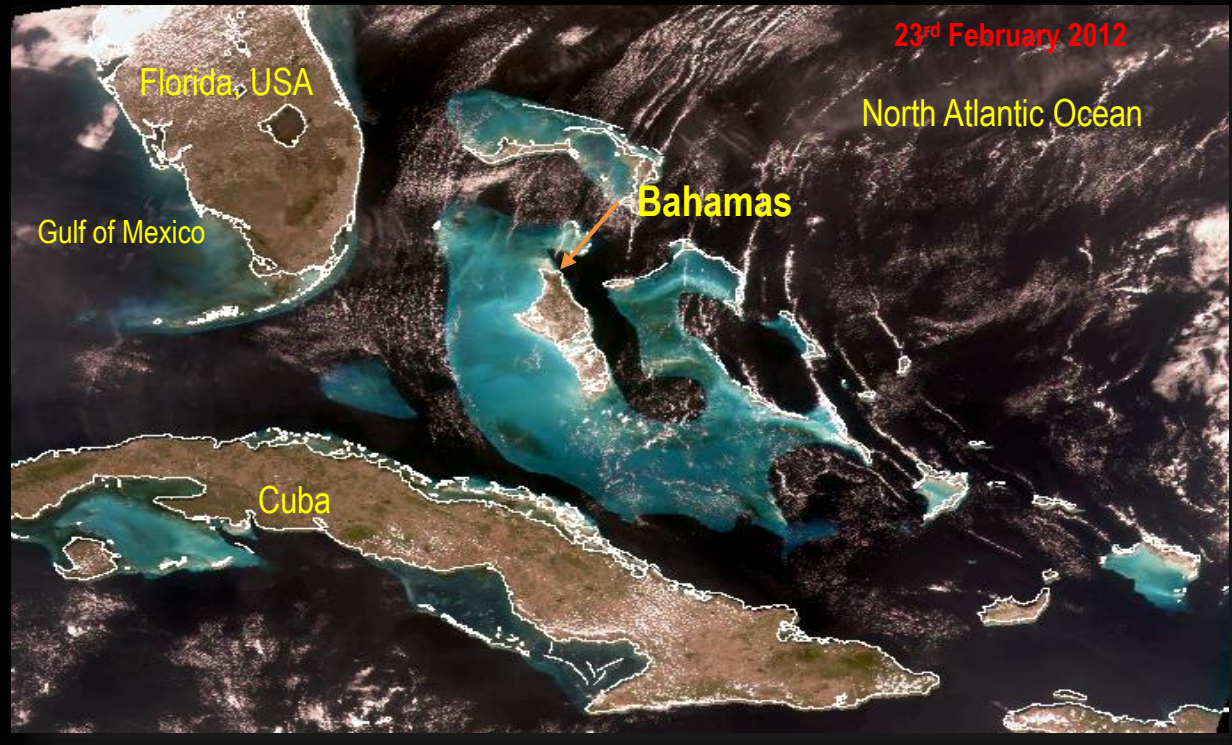
The atolls boundaries, comprising of coral reefs sitting over the extinct volcano or caldera, are shown in green colour. Inside the green rim exist the lagoons, shown in black colour. Also, a number of islands exist within these green polygons.

The Oceanic & Aquatic Biosphere

Coral Reefs

Bahamas Corals

The Bahamas have chain of islands and all islands are surrounded by corals. They have the third most extensive coral reef system in the world (5% of the world's corals are concentrated here) and is famous for its deep water sponges and for its Nassau Grouper spawning aggregation sites. Despite huge tourism in this region, there are around 17 marine protected areas.



This OCM-2 image shows south Florida, Cuba and Bahamas corals. Bahamas corals exist as turquoise patches in the deep blue Atlantic ocean.

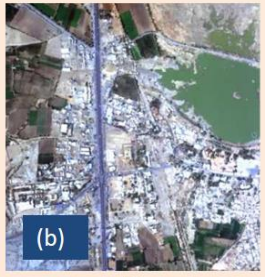
The Oceanic & Aquatic Biosphere
Colour of Inland Water Bodies

Inland water bodies represent that part of the biosphere where marked biological diversity, complex biogeochemical pathways and an array of energetic processes occur. They include, rivers, lakes, ponds, reservoirs, wetlands, floodplains and inland saline water systems. Geographically, they acquire as smaller share but from ecological point of view, they provide biospheric diversity, structure and function.

Inland water bodies can be fresh, saline or brackish. Although, named as sea, Caspian sea (fresh water) and Dead sea (hyper-saline) fall into the category of inland water bodies.

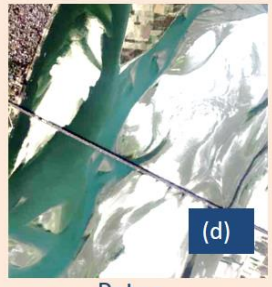
Coastal & Inland Water Quality from Space

Ahmedabad



Surendranagar

Desalpar



Patna

Himachal Pradesh

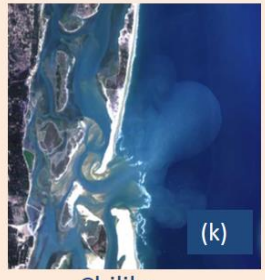
Bhagalpur

Muddumalai

Hooghli

Sundarban

Bhitarkanika



Chilika

Veeraval

Variables from space

- ***Turbidity***
- ***Chlorophyll-a***
- ***Light attenuation***
- ***CDOM***
- ***Surface Temp***
- ***Eutrophication***

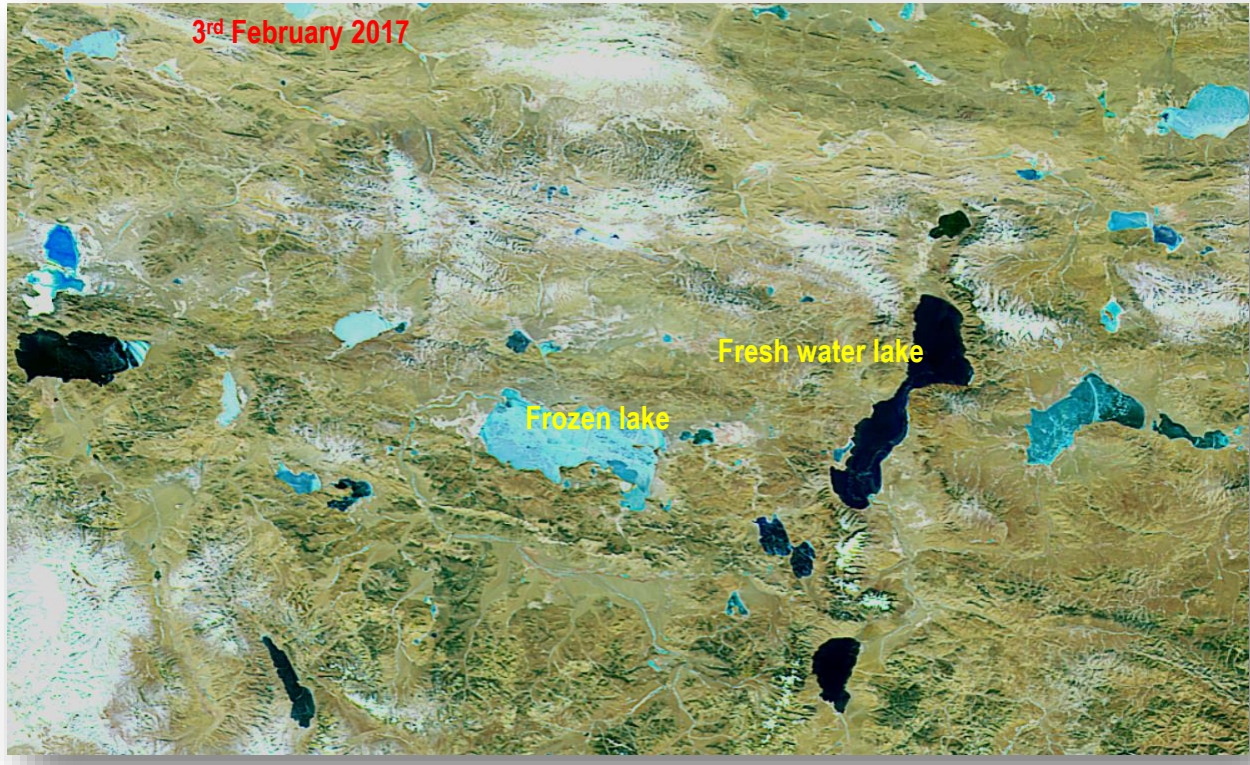
Water Quality is essential for human, ecosystem and economic health. Degradation of water quality can result in human exposure to disease, reduction of productivity and diversity of ecosystem & agriculture.

The Oceanic & Aquatic Biosphere

Colour of Inland Water Bodies

High Altitude Tibetan Lakes

Tibet has largest number of alpine lakes. Lakes in North Tibet are formed by continuous crustal movement while those of south are formed from mudslides, volcanic eruptions and snow melting.



During winter temperature drops in Tibetan plateau region to below zero and many of these high altitude lakes shows freezing, however few lakes do not freeze. This is generally attributed to high salinity as freezing point of highly saline waters is much lower.

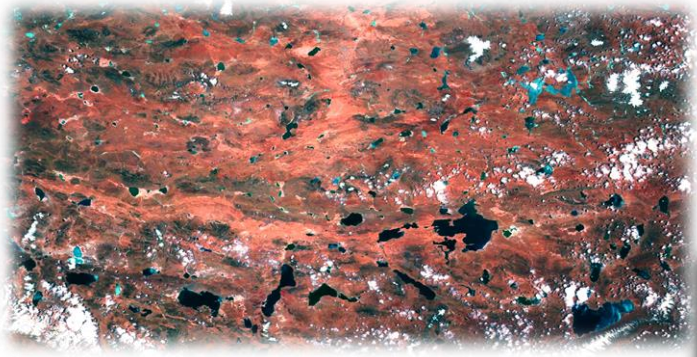
The Oceanic & Aquatic Biosphere
Colour of Inland Water Bodies

Lake Mansarovar

is the freshwater lake near Mount Kailash, at a height of around 15000ft. It is believed to be a lake of high religious significance in Hinduism, Jainism, Buddhism and Bon religions

Rakshastal

is the saltwater lake near Mansarovar lake. It is believed to be a 'lake of demons'.



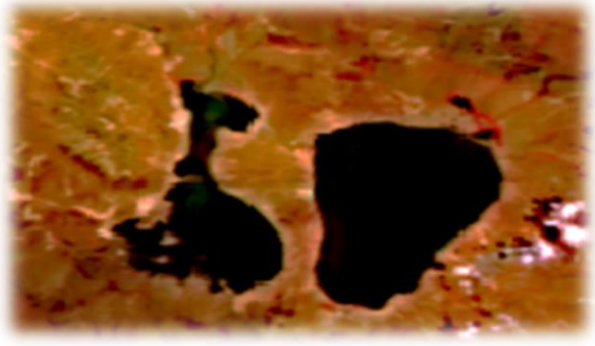
High altitude Tibetan lakes showing hues of water depending upon the frozen and otherwise conditions.

Mansarovar lake and Rakshastal exist geographically near to each other but the colour of both the lakes is significantly different owing to the difference in mineral composition which leads to frozen condition of Rakshas Tal.

24th January 2017

10th September 2017

The September False Colour Composite image of both the lakes show identical water colour pertaining to the higher temperatures causing snow-melt. This part of the year is suitable for various trekking expeditions.



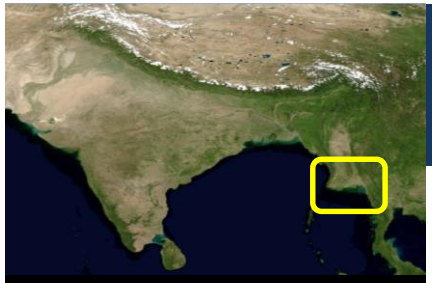
The Oceanic & Aquatic Biosphere
Coastal Turbidity

Turbidity is a measure of water clarity or murkiness. It is an optical property that describes the extent to which light gets scattered and absorbed by the molecules and type of particles present in water. Turbidity results from Colored Dissolved Organic Matter (CDOM) like humic substances, suspended particles like sand and silt, detritus and micro-organisms like algae.

Degree of turbidity is a means to study the state of water bodies. Increase in turbidity reduces the amount of light available for photosynthesis to the marine life and hence disturbs the entire system.

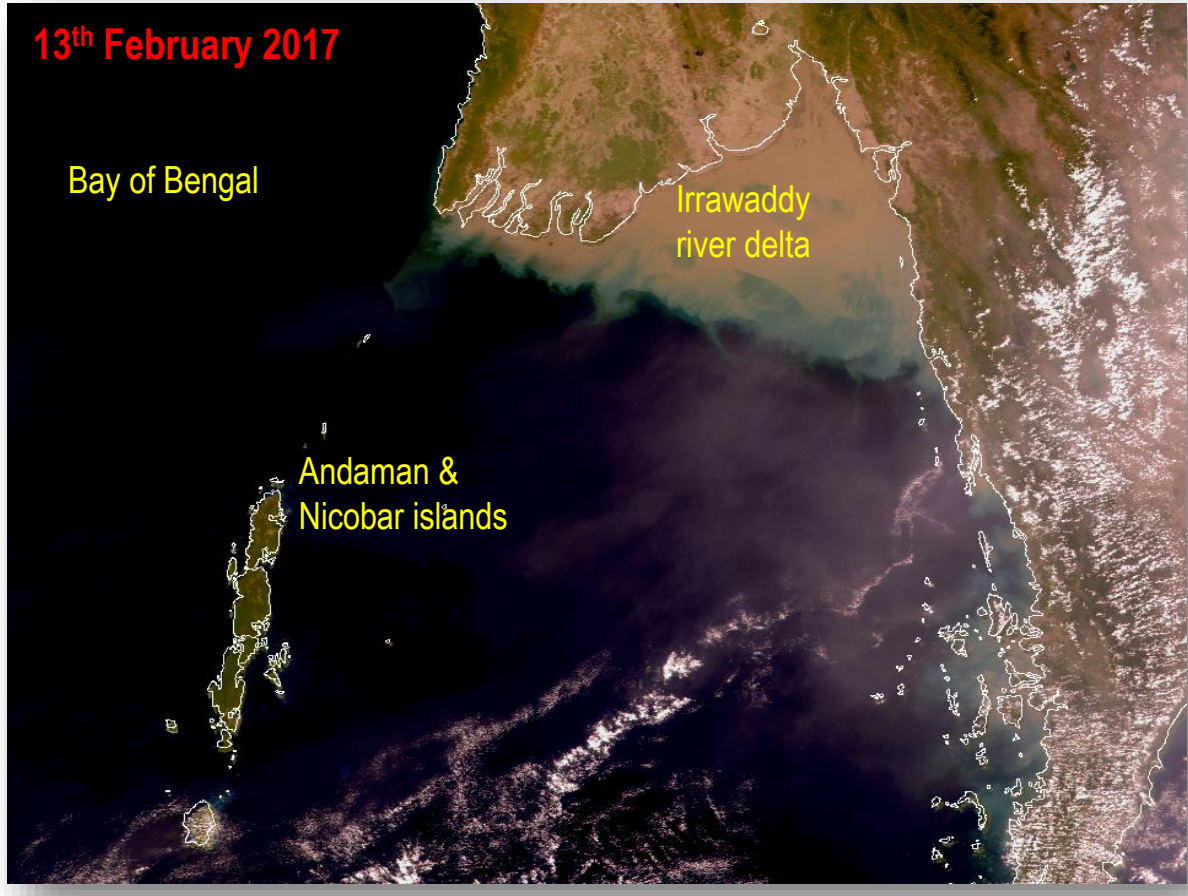
In general, turbidity is low in wave dominated coastal systems while high in tide dominated systems.

The Oceanic & Aquatic Biosphere
Coastal Turbidity



Irrawaddy river Delta

The Irrawaddy is the principal river of Myanmar and rises in the folded ranges of northern Myanmar. It's several distributary channels, Rivers Pathein, Pyapon, Bogale and Toe form this extensive delta system into the Andaman Sea. The region is ecologically rich and densely populated. All the rivers are highly turbid due to heavy silting as a result sea area along the coast is also very shallow. Owing to constant accretion in the sea, delta is advancing at the rate of 5-6 km per 100 years.



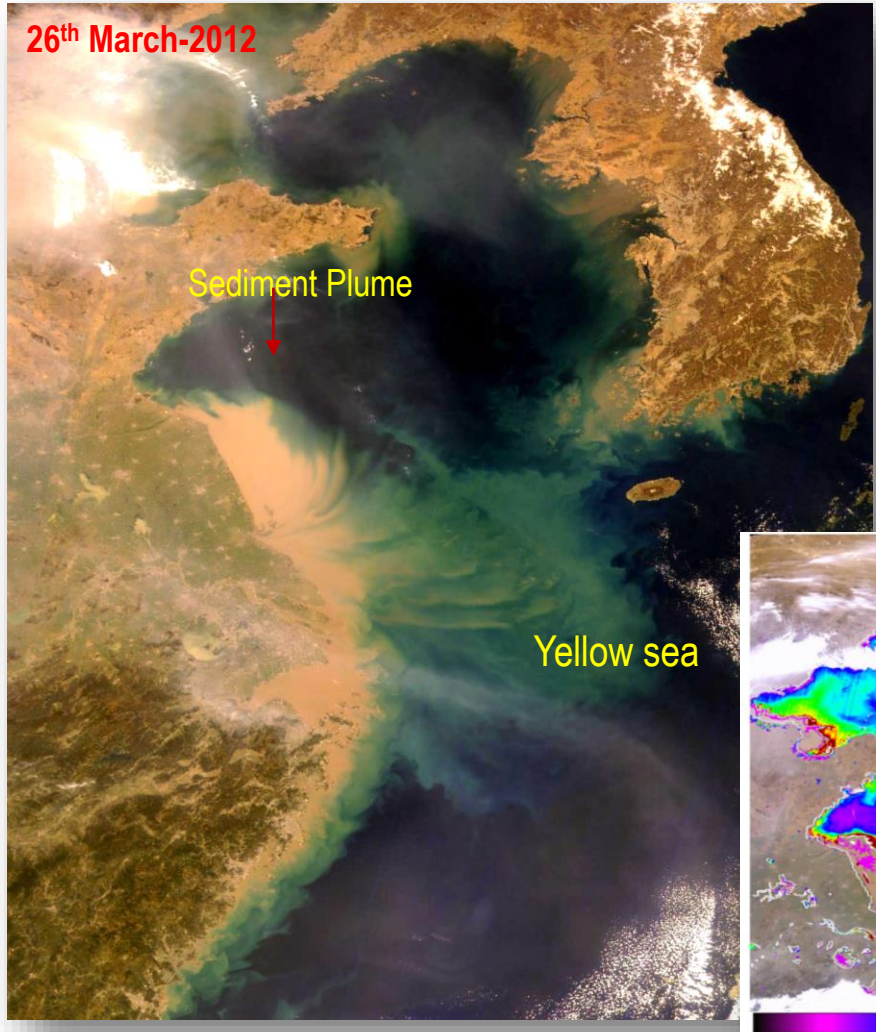
This true colour image of Irrawaddy river delta shows heavy sediment discharge, owing to the four highly turbid rivers, into the sea thereby giving the muddy look. The muddy water diffuses with the blue Bay of Bengal waters. Presence of phytoplankton communities give the characteristic green colour to the water.

The Oceanic & Aquatic Biosphere

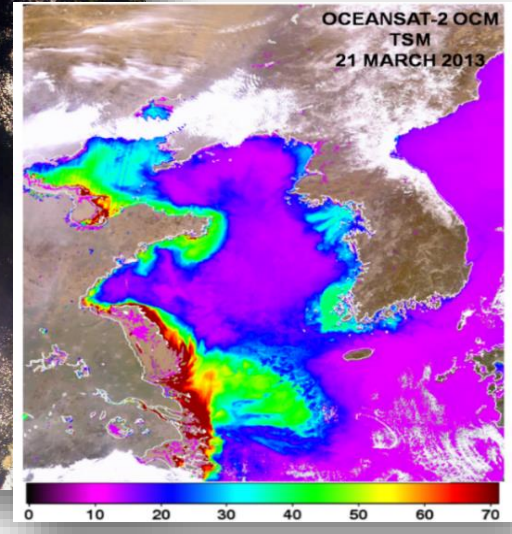
Coastal Turbidity

Yellow Sea, China

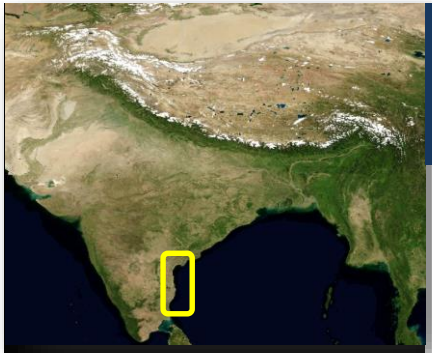
Lies between mainland China and Korean Peninsula. It is one of the world's largest continental shelf covered in shallow water. It has rich fishing grounds and provides a huge platform for migratory birds



This true colour image of Yellow sea, China shows deep muddy waters resulting from the rivers' discharge of high mineral content sediments. This huge sediment dumping gives the characteristic yellow colour to the sea, and hence the name. Along the coast, phytoplankton patches can be seen (blue-green waters).

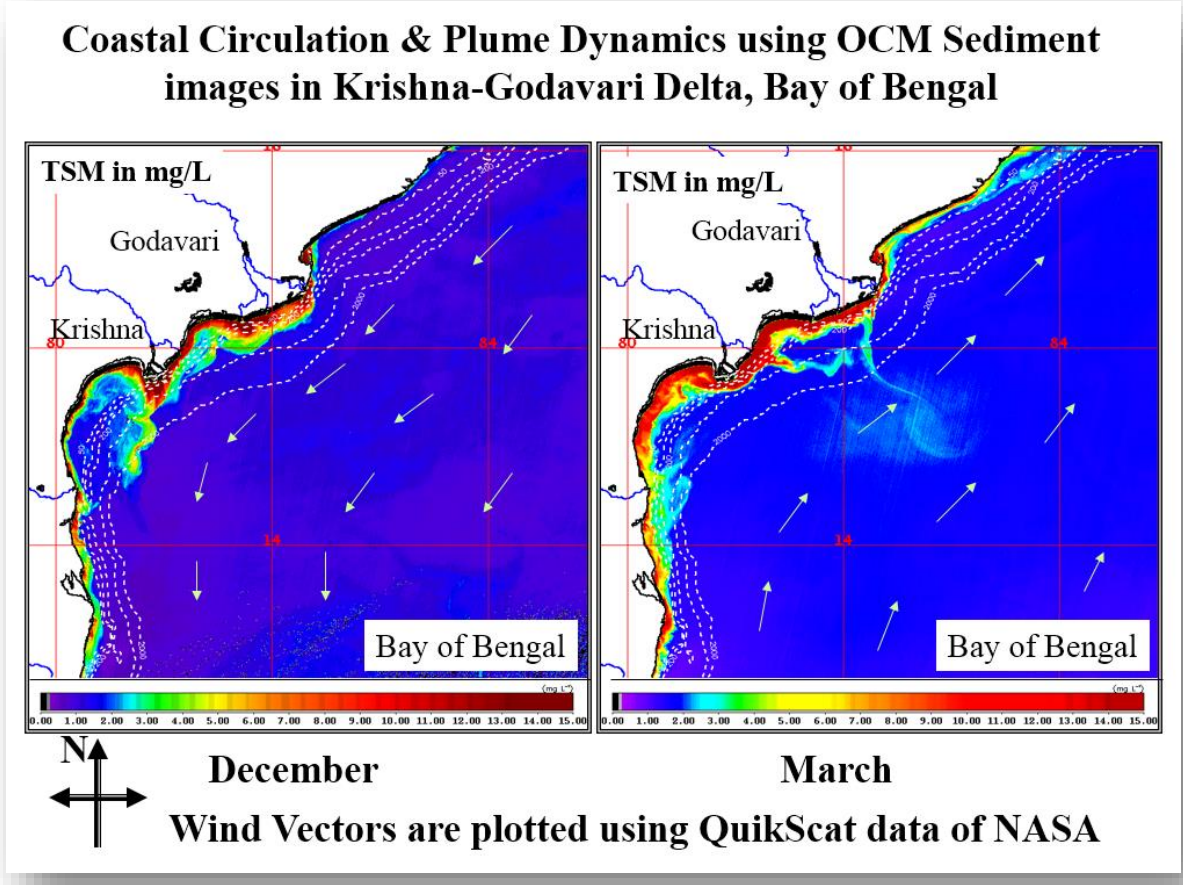


The Oceanic & Aquatic Biosphere
Coastal Turbidity



Krishna-Godavari Delta

Krishna and Godavari rivers, the two important rivers of peninsular India, emerge from the state of Maharashtra, coalesce into big delta system in the eastern part of the country. Together, their drainage system constitute ~17.4% of the country's total geographic area. The sediment dumping from both the rivers into the Bay of Bengal is tremendous in the monsoon season, however, otherwise Godavari river bears comparatively higher sediment load.



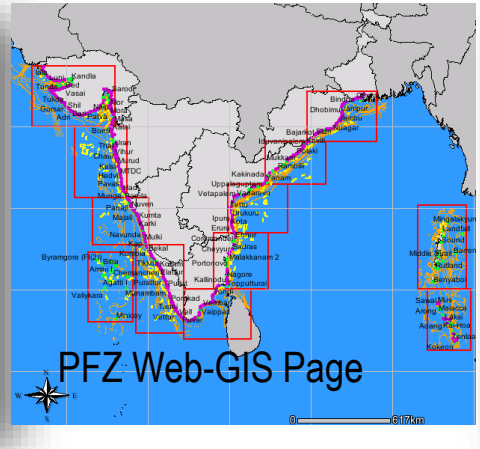
Total Suspended Matter along the entire delta system is extremely high throughout the year (of the order of 10-15 mg/L). However, during December when South-west winds dominate, the sediment plume flows south while during March when North-east winds prevail, the direction of sediment plumes turn eastwards.

The Oceanic & Aquatic Biosphere
Ocean Colour for Fisheries

Fishing is a livelihood for around 7 million people in India. Identifying the fishing grounds and then catching are important but difficult aspects. Timely and accurate advisory about the fishing grounds would come as a great help for the fishing community.

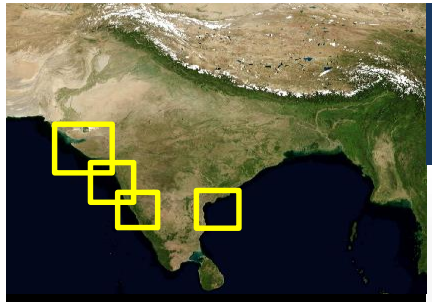
Ocean colour sensors have the capability of identifying the potential fishing zones and that too, very accurately and timely. The underlying principle is the identification of phytoplankton colonies on which the fishes thrive.

Under the Potential Fishing Zone (PFZ) advisory, PFZ maps (including landing centers, bathymetry and location) are provided to all the 14 sectors along the Indian coastline.



The Oceanic & Aquatic Biosphere

Ocean Colour for Fisheries

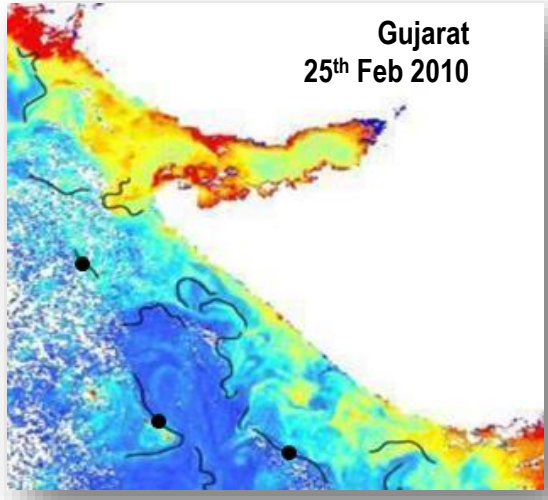


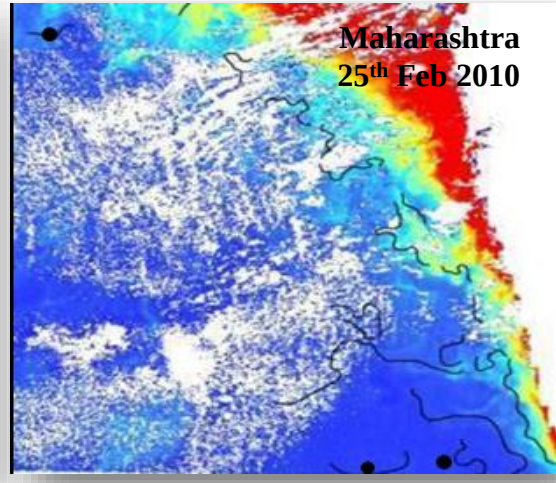
Oceanic fronts are associated with zones of elevated primary and secondary production and fishery grounds .

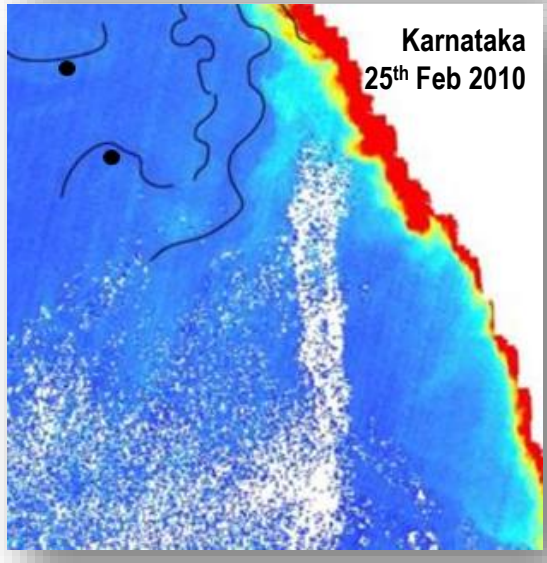
Upwelling zones, eddies and rings are known to be rich in nutrients leading to higher productivity.

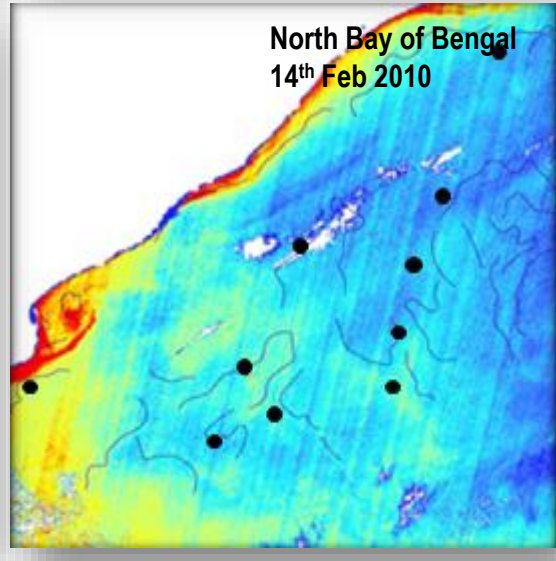
Persistent ocean features are relatively good for fishing for longer duration.

Large fishing grounds (warmer tones) fall in concurrence with the chlorophyll fronts.









The Oceanic & Aquatic Biosphere

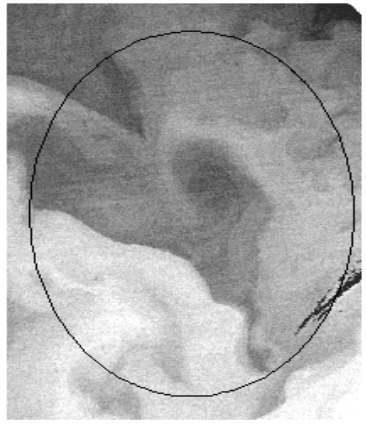
Ocean Colour for Fisheries

Oceanic thermal fronts are often associated with zones high phytoplankton concentration.

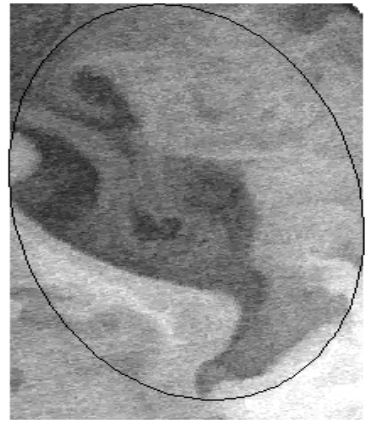
The images of NOAA AVHRR thermal data are compared with the Oceansat-1 OCM derived phytoplankton maps which shows the cooler upwelled water are associated with high chlorophyll content.

Application of thermal and ocean colour data togather are found to be very useful for identification of productive zones in the ocean.

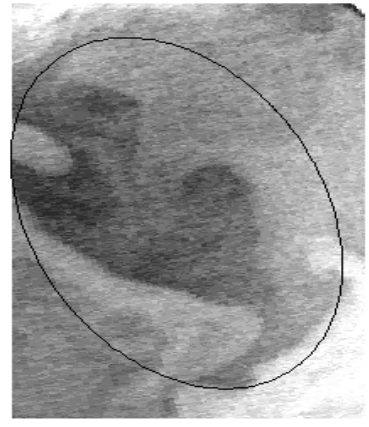
SST (NOAA AVHRR)
February 25, 2000



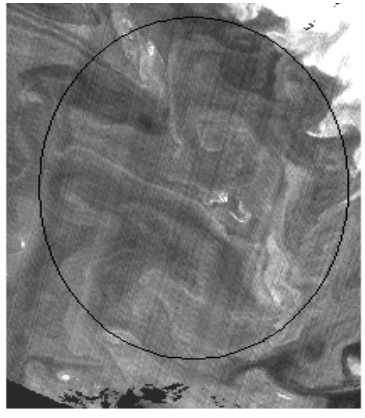
SST (NOAA AVHRR)
February 28, 2000



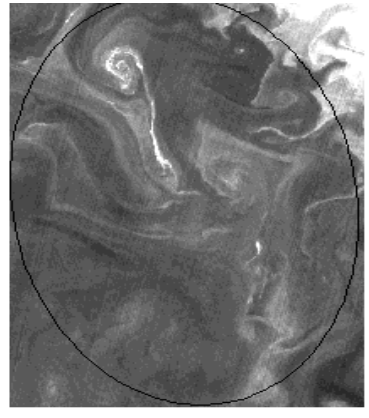
SST (NOAA AVHRR)
February 29, 2000



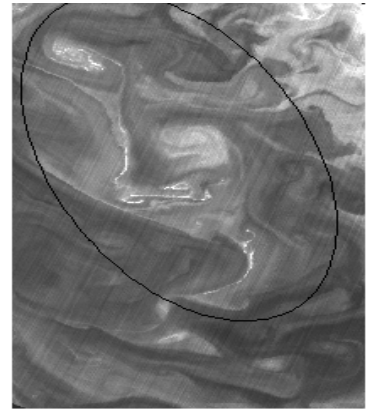
Chlorophyll (Oceansat-1 OCM)
February 25, 2000



Chlorophyll (Oceansat-1 OCM)
February 27, 2000



Chlorophyll (Oceansat-1 OCM)
February 29, 2000



The Oceanic & Aquatic Biosphere
Ocean Colour for Fisheries

PFZ Mission

R & D Efforts, Modelling Technology Development

Operational Generation of PFZ Maps from remote sensing products: SST, Chlorophyll and Wind (Except during Marine Fishing Ban Period)

Dissemination
Multi-lingual Delivery (Map, Text), Fax, Phone, News Paper, Internet, e-mail, Electronic Display Boards, Radio and TV Broadcast, Information Kiosks (VKC, VRC)

Fishing Vessels

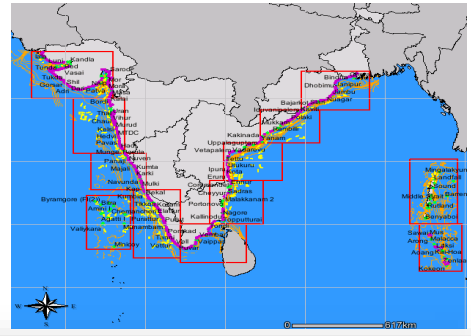
Partners : SAC, NRSC, FSI, CFRI, Academia, State Fishery Departments, Fisherman Association

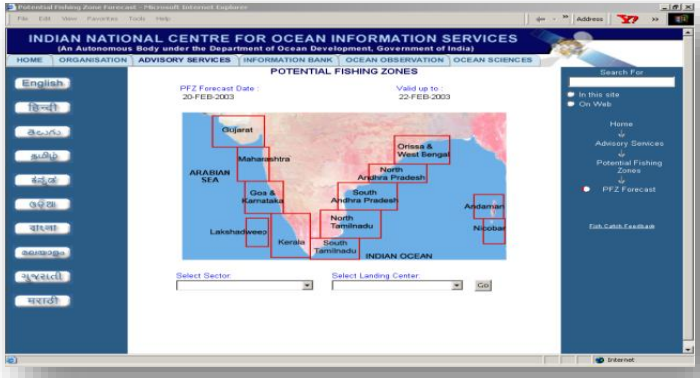
Validation/ Feedback

User Awareness

Potential Fishing Zone (PFZ) Mission:

To make the potential fishing zone advisories as part of the value chain of fishing community

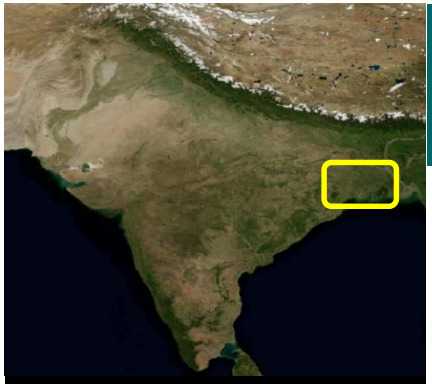




The Terrestrial Biosphere
Mangrove Ecosystem

Mangroves are salt tolerant shrubs or small trees that are well adapted to harsh coastal conditions. They generally occur in tropics and sub-tropics. Mangrove species are physiologically adapted to anoxia, frequent tidal inundation and high salinity.

Mangrove ecosystems provide coastal protection against erosion by storm surges, waves and tides. They have well developed root system that make these forests attractive to fishes and other organisms seeking food and protection from other predators.

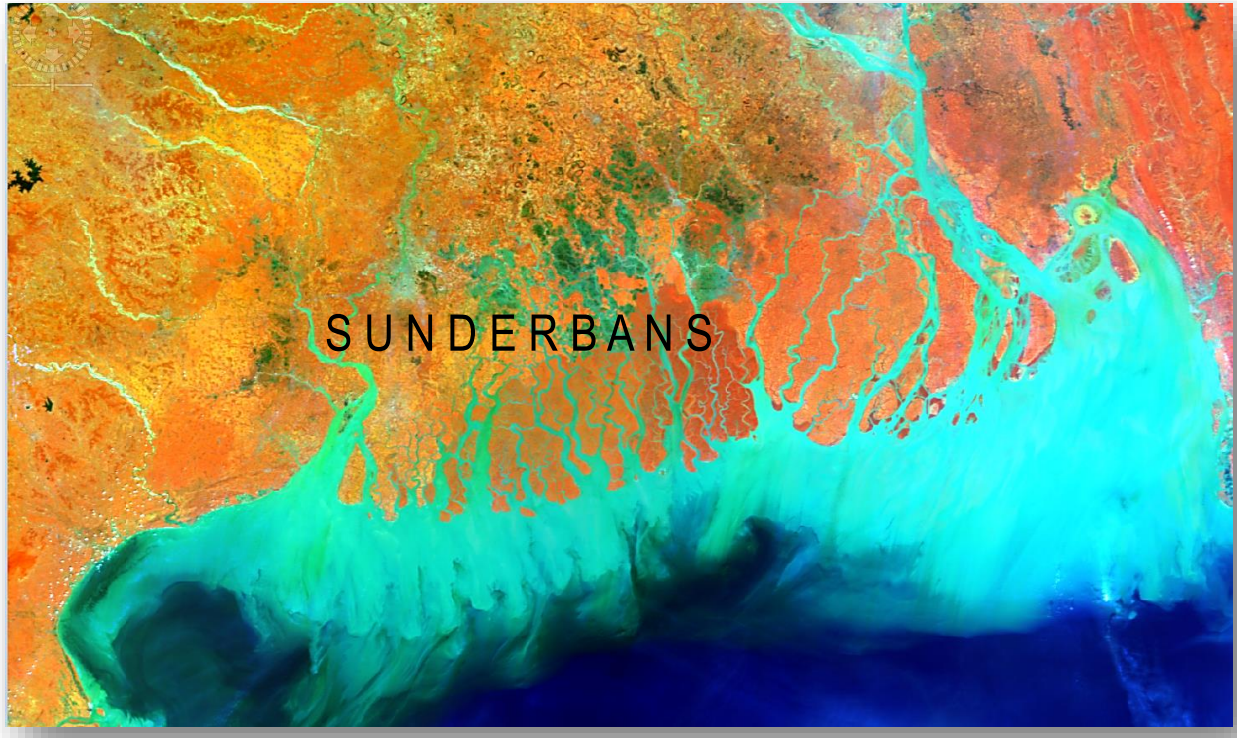


The Terrestrial Biosphere

Mangrove Ecosystem

Sunderbans Mangroves

Sunderbans is a vast forest near Bay of Bengal and is recognized as UNESCO world heritage site and Ramsar ecological site. It is the world's largest delta system and also the home of world's largest coastal mangrove forests. Out of 10,000 sq km of mangrove forests, 40% fall in India while the rest in Bangladesh. Heriteria fomes, popularly known as sundari is the dominant mangrove species in this area.

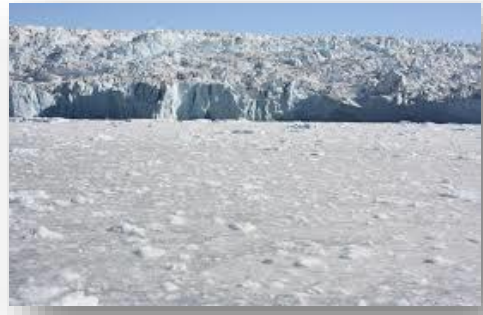


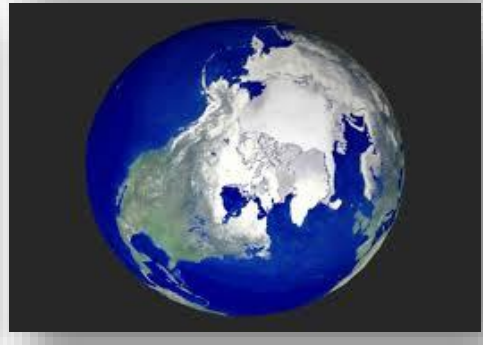
This image from OCM-2, dated 6th November 2017 shows the majestic Sunderbans mangroves. Also, being the largest delta system, the water at the delta appears to be highly turbid due to the heavy discharge from all the river systems. These sediments in turn help in making this region fertile and is thus a home to a variety of flora and fauna.

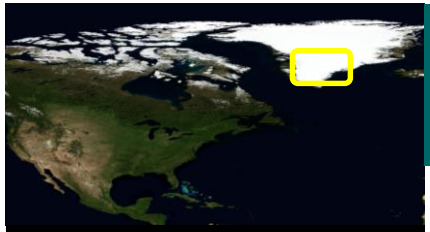
The Terrestrial Biosphere
Polar and Sea Ice

Sea ice cover is an important parameter to find the polar response towards climate change. It's study is important for navigation purposes as well as for forecasting oceanic circulation and climate change. Sea ice acts as a thin layer between ocean and atmosphere at the poles. Satellite remote sensing acts a good means to monitor it.

Satellite remote sensing can also be used for monitoring snow cover over Himalayas. This would help to give an insight to the factor of climate change.





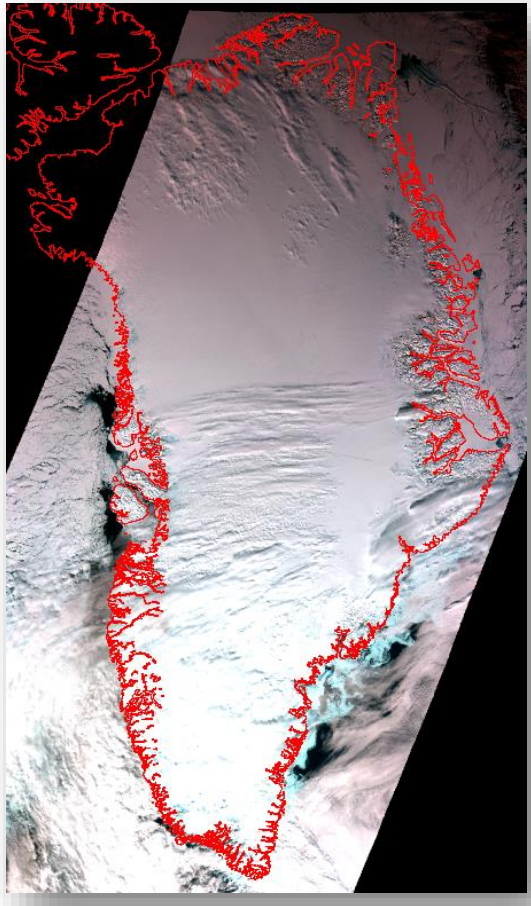


The Terrestrial Biosphere
Polar and Sea Ice

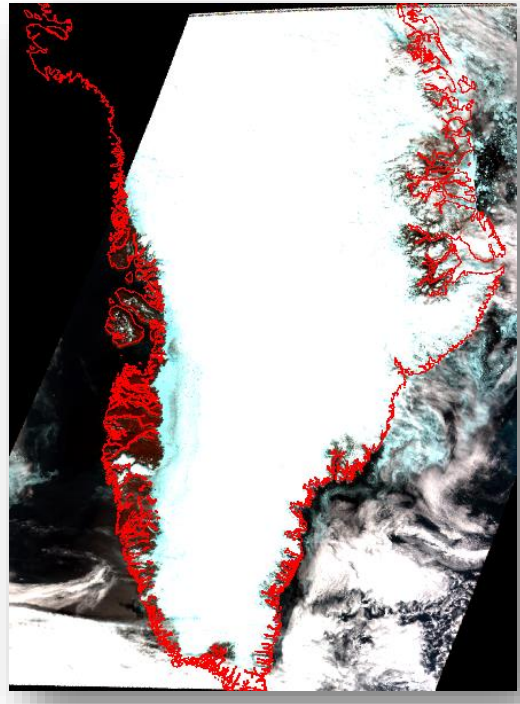
Greenland

It is the largest island of the world. More than 3/4th of it has permanent ice cover. The region is home to good variety of fishes and invertebrates, around 700 species of insects and 450 species of higher plants.

15th March 2012



29th June 2012

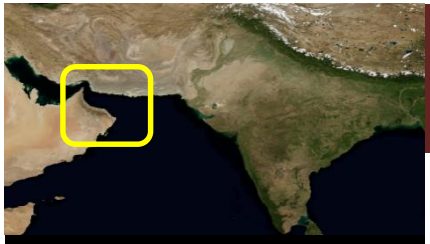


These two images from OCM-2 show the variability in the ice cover

Natural Hazards and Disasters
Dust Storm

Dust storm is a meteorological phenomenon, common in arid and semi-arid regions, caused by strong gust of wind that erodes huge volumes of sand and silt through the process of saltation and suspension. The main sources of dust are Arabian desert and deserts of North Africa, especially The Sahara.

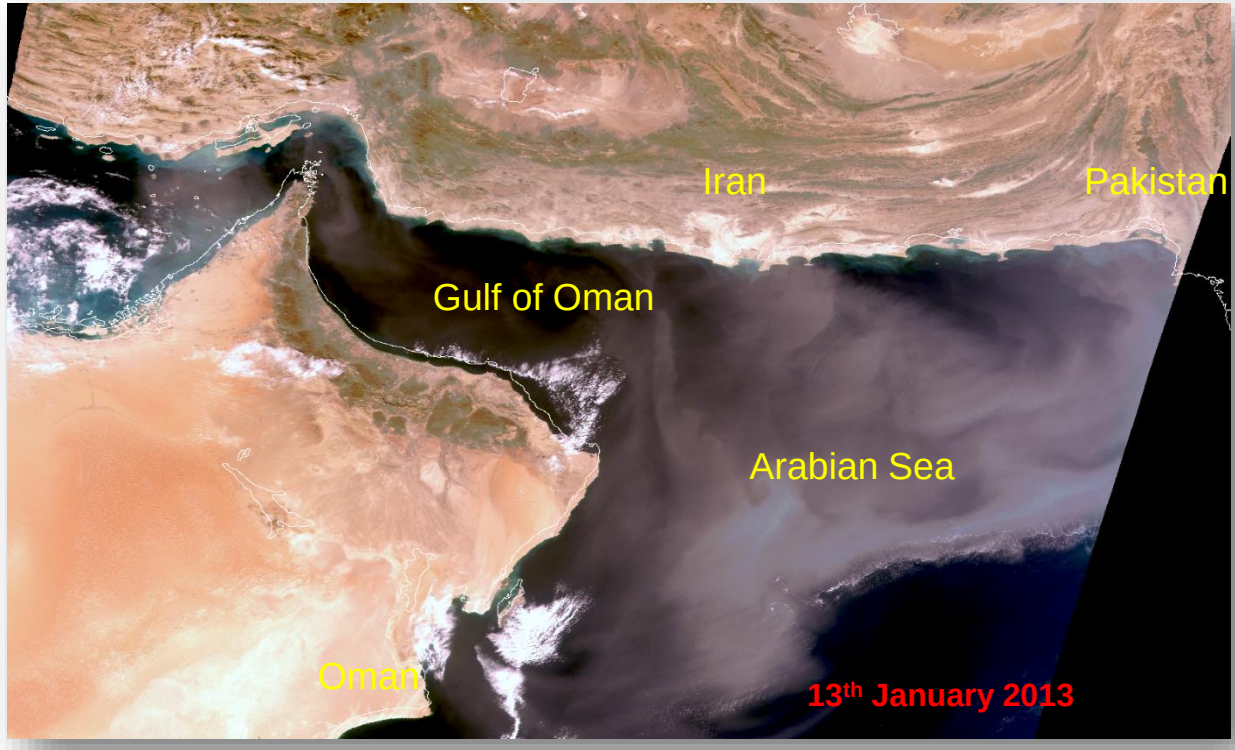
Over the recent years, dust storms have become more frequent and of large size. The reason is generally attributed to the poor land-use practices, for e.g., leaving the crop lands fallow for a long time, mass deforestation etc.



Natural hazards and Disasters
Dust Storm

The Shamal effect

During winters, westerly depressions in the regions of Strait of Hormuz and Gulf of Oman cause dust storm wherein dust blows off from Iran and neighboring areas. Local phenomenon called 'Shamal' causes these dust storms of very high velocity (often greater than 25 knots) and extreme weather conditions.

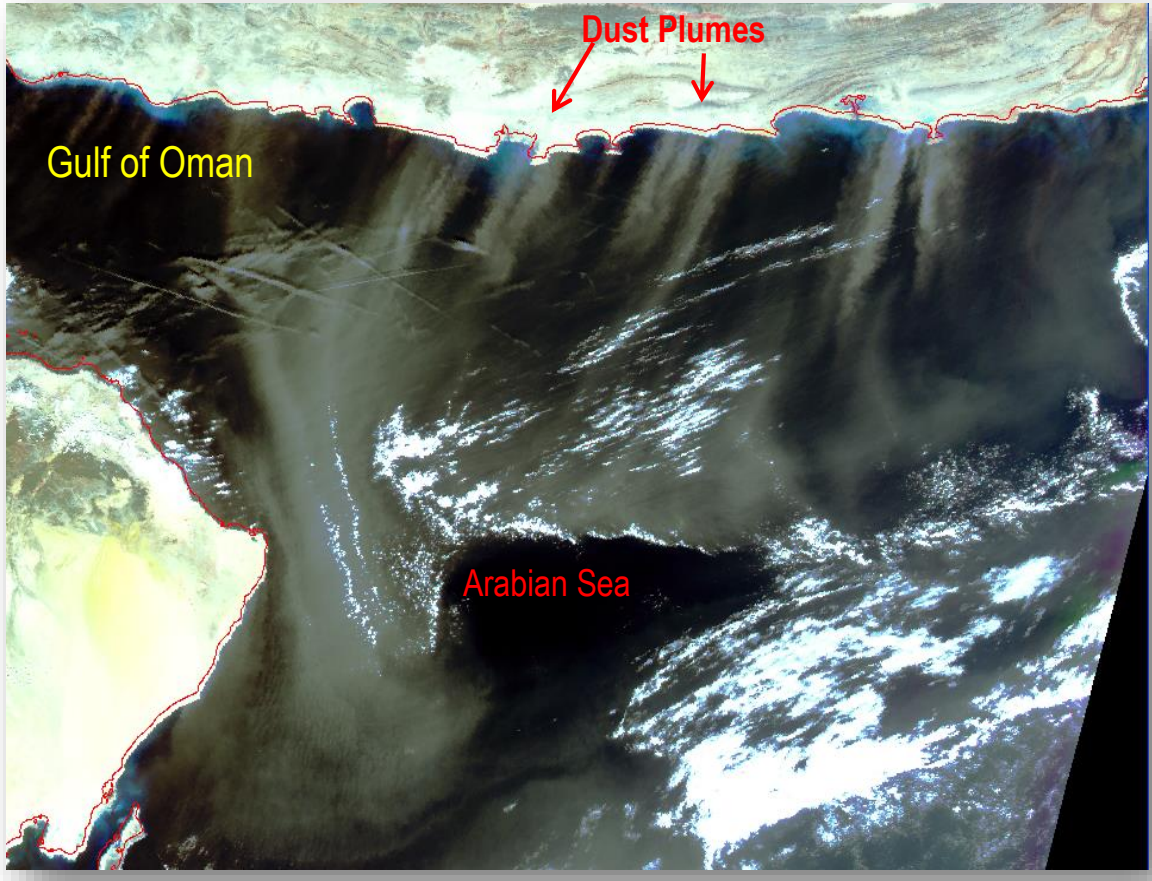


In early January 2013, dust storm of almost 30 knots blew off the Arabian sea affecting Oman, Iran and Pakistan. OCM-2 captured the dust spread, caused by Shamal effect, over the Gulf of Oman and Arabian sea. The dust layer was thick thereby reduced the visibility, especially across the rivers and canyons. Once the wind speed dropped down to less than 15 knots in 3-4 days time span, the visibility was regained.

Natural hazards and Disasters

Dust Storm

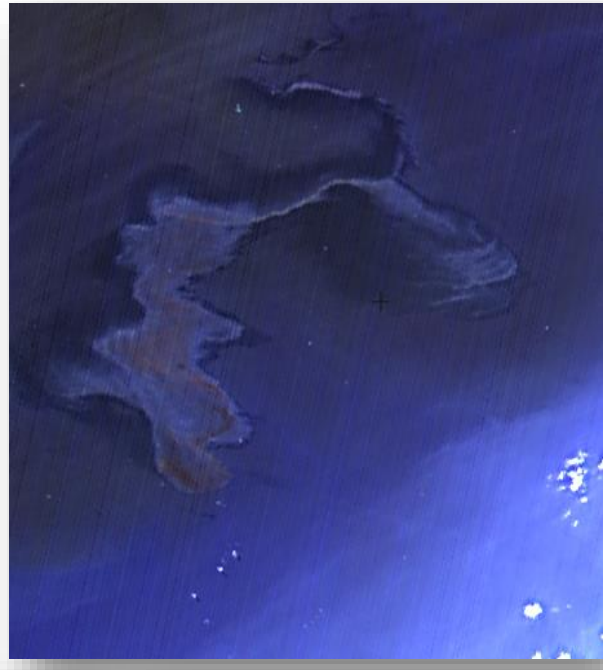
Desert dust over the Arabian sea captured by OCM -2 on February 4, 2012



Natural Hazards and Disasters
Oil Slick

Oil slick is a layer of oil spread over the large surface of the waterbodies, especially sea. It is an outcome of oil spill from the ships and containers, which may be accidental or sometimes intentional.

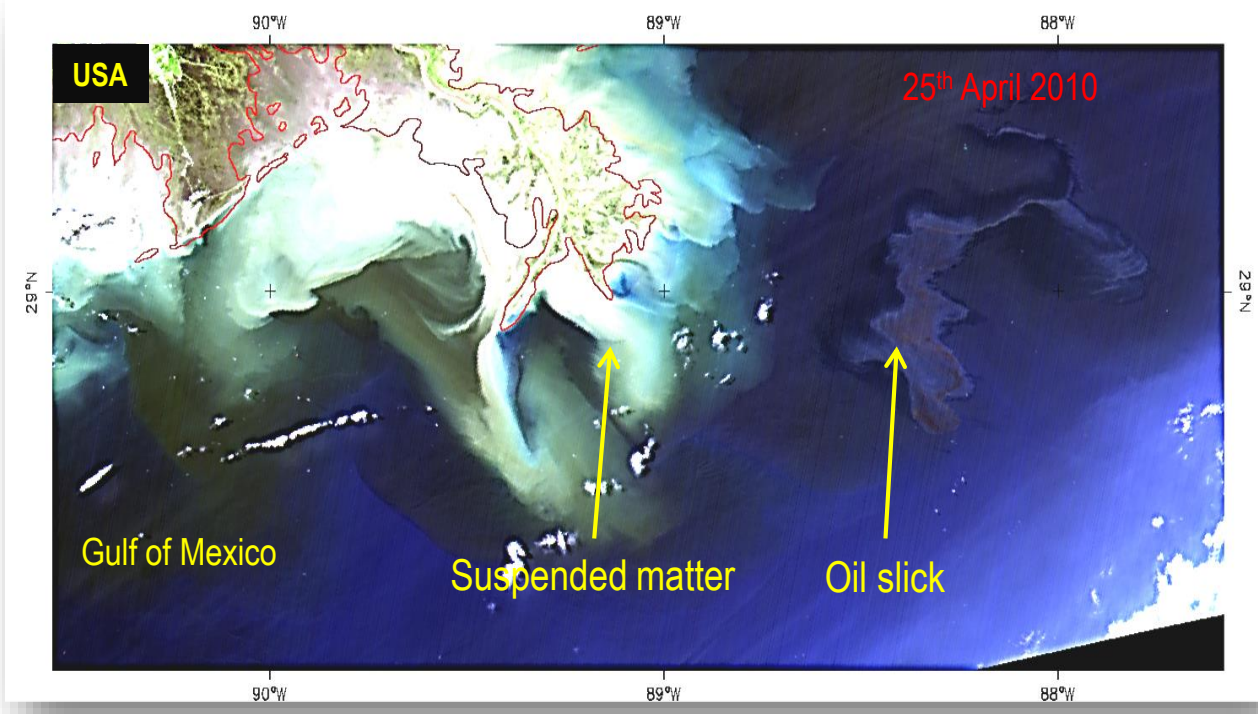
Oil slick largely destructively affects the marine ecosystem both as a physical smothering and also due to toxic effects.



Natural hazards and Disasters

Oil Slick

The Deep water Horizon oil spill was an oil spill in the Gulf of Mexico considered the largest accidental marine oil spill in the history of the petroleum industry. A sea-floor oil gusher flowed for 87 days, until it was capped on 15th July 2010. Due to the months-long spill, along with adverse effects from the response and clean-up activities, extensive damage to marine and wildlife habitats, fishing and tourism industries, and human health problems have continued through 2013.



This image shows a huge patch of oil slick spread over blue waters of Atlantic ocean

Natural Hazards and Disasters
Cyclone

Cyclone is a large air mass revolving around a center of low atmospheric pressure. They are characterized by inward spiraling winds. Generation and strengthening of tropical cyclones occur if the following conditions get fulfilled-sufficiently warm sea surface temperature, atmospheric instability, high humidity, low vertical wind shear and enough Coriolis force.

On an average 86 cyclones form in a year with around 47 reaching to the level of hurricane or typhoon and 20 rise to category 3, which is the most severe.

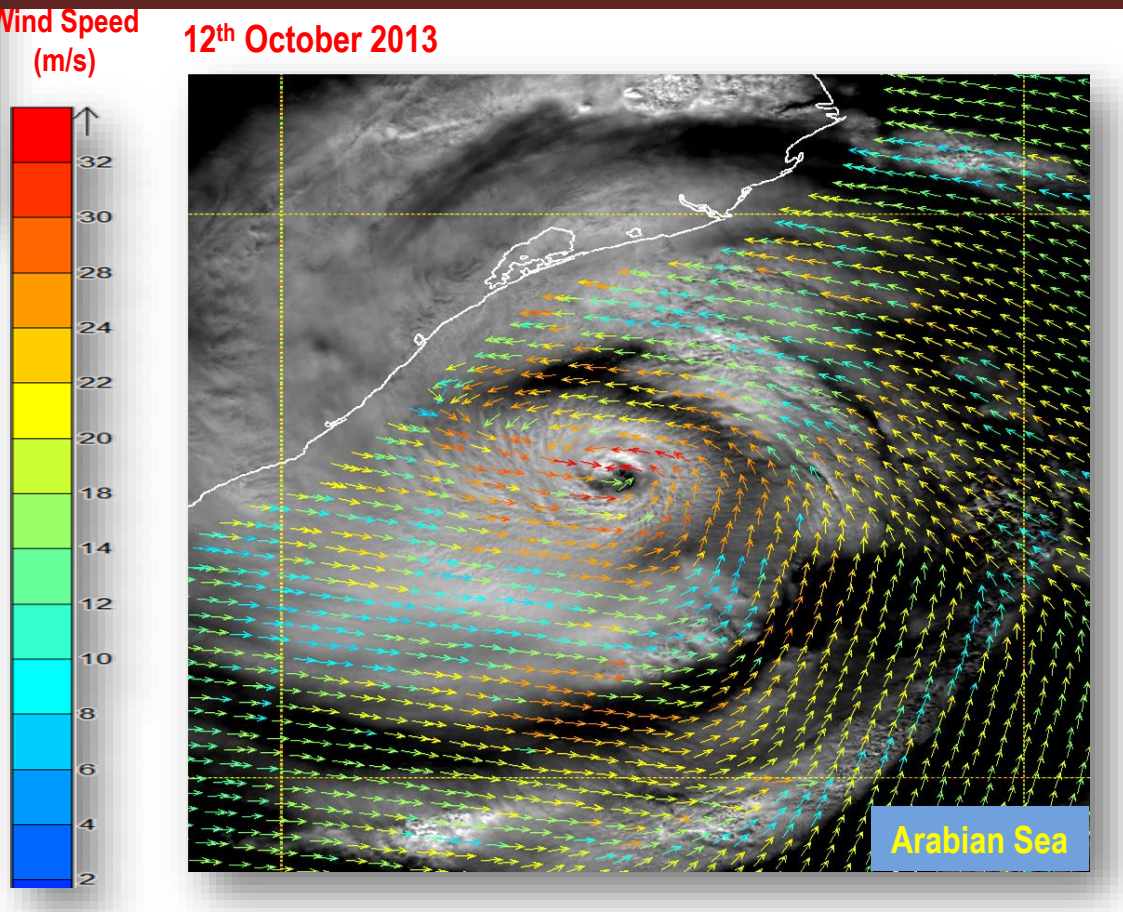
The recent most cyclones hitting Indian landfall are Ockhi in 2017, Vardah in 2016, Phailin in 2013 etc.

Natural hazards and Disasters

Cyclone

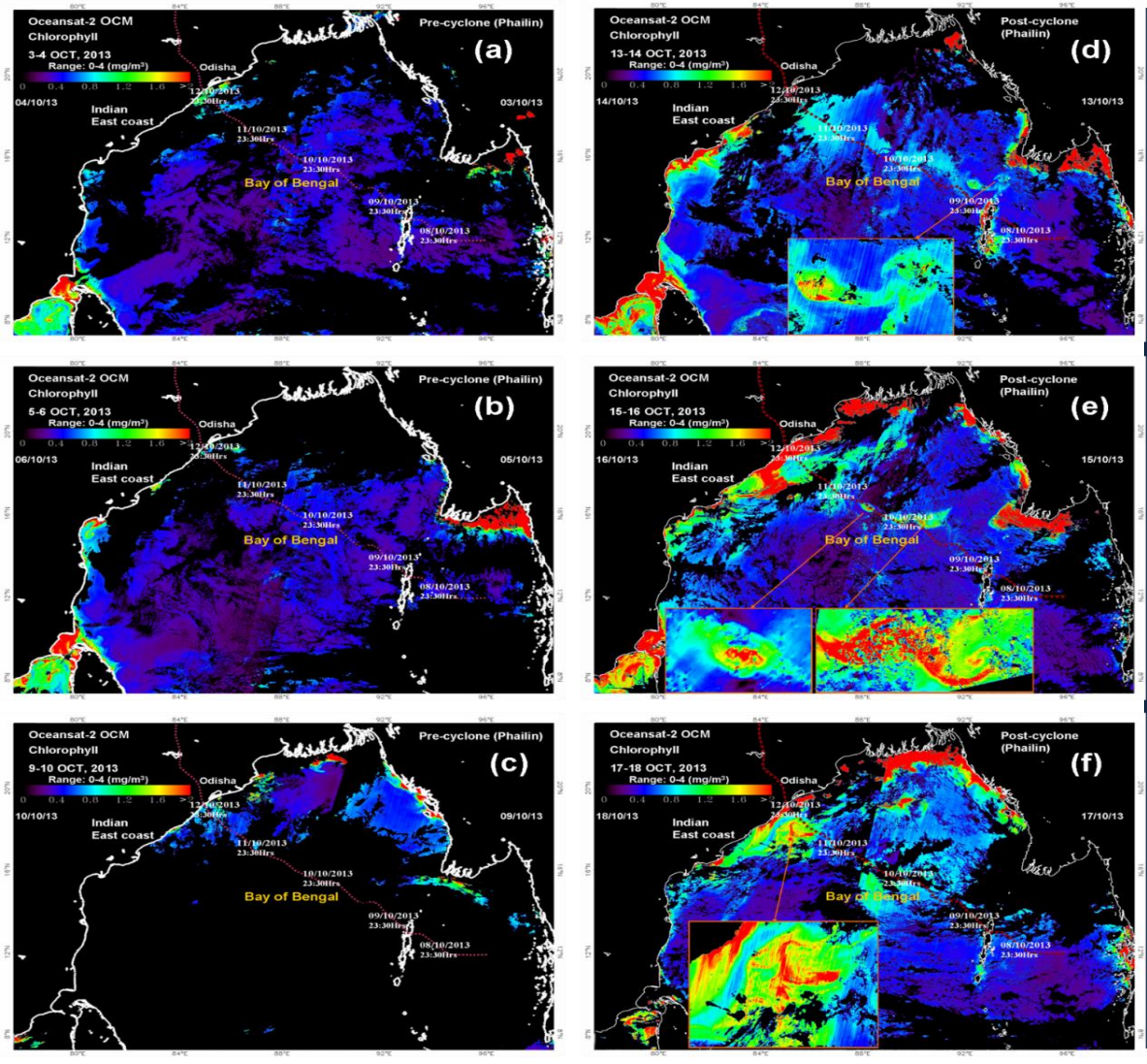
Cyclone Phailin

Was the extremely severe cyclonic storm that hit the Indian landfall in 2013. It affected almost 12 million people of the country. The highest wind speed reached ~215km/h.



OCEANSAT-2 OCM B1 360 m Image overlaid by OCEANSAT-2 Scatterometer 12.5 Km Wind Vector. The image shows high speed winds at the eye of the cyclone and dissipated energy at the outer parts. As the cyclone settles down, the churning of oceanic water caused by it makes various parts of the region fertile and allows significant phytoplankton succession.

Cyclone Induced Productivity



Cyclone Phailin

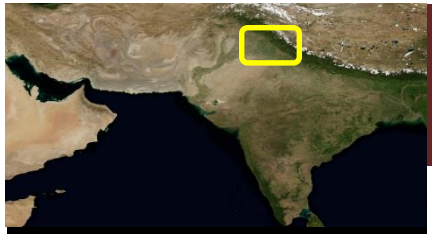
When a cyclone passes over the ocean it churns the water beneath on its path. This churning creates upwelling and brings nutrient rich water from below the ocean to the surface enhancing growth of phytoplankton along it's path. This phenomena was noticed during October 2013, when the super cyclone Phailin passed over Bay of Bengal. The pre cyclone and the post cyclone images of Oceansat 2 clearly indicates the effect of cyclone on ocean productivity.

Natural Hazards and Disasters
Winter Haze and Fog

Fog is made of tiny liquid water droplets, small enough to remain suspended in the air and causing all lights incident on it to be reflected off in all directions, thereby leaving behind a white vale. This largely obscures the visibility to less than 1km and increases relative humidity to 95%. When the pollutants amalgamate fog, it is termed as smog and is more dangerous-primarily because it significantly reduces the visibility and secondly because it adversely affects the human health.

Haze is an atmospheric phenomenon in which the dust, smoke and other air pollutants obscure the clarity of the air.

In the recent times, the north Indian belt, over the entire Indo-Gangetic plain experiences winter haze, fog and smog. Satellite data, in such case, becomes extremely useful for forecasting and monitoring purposes.

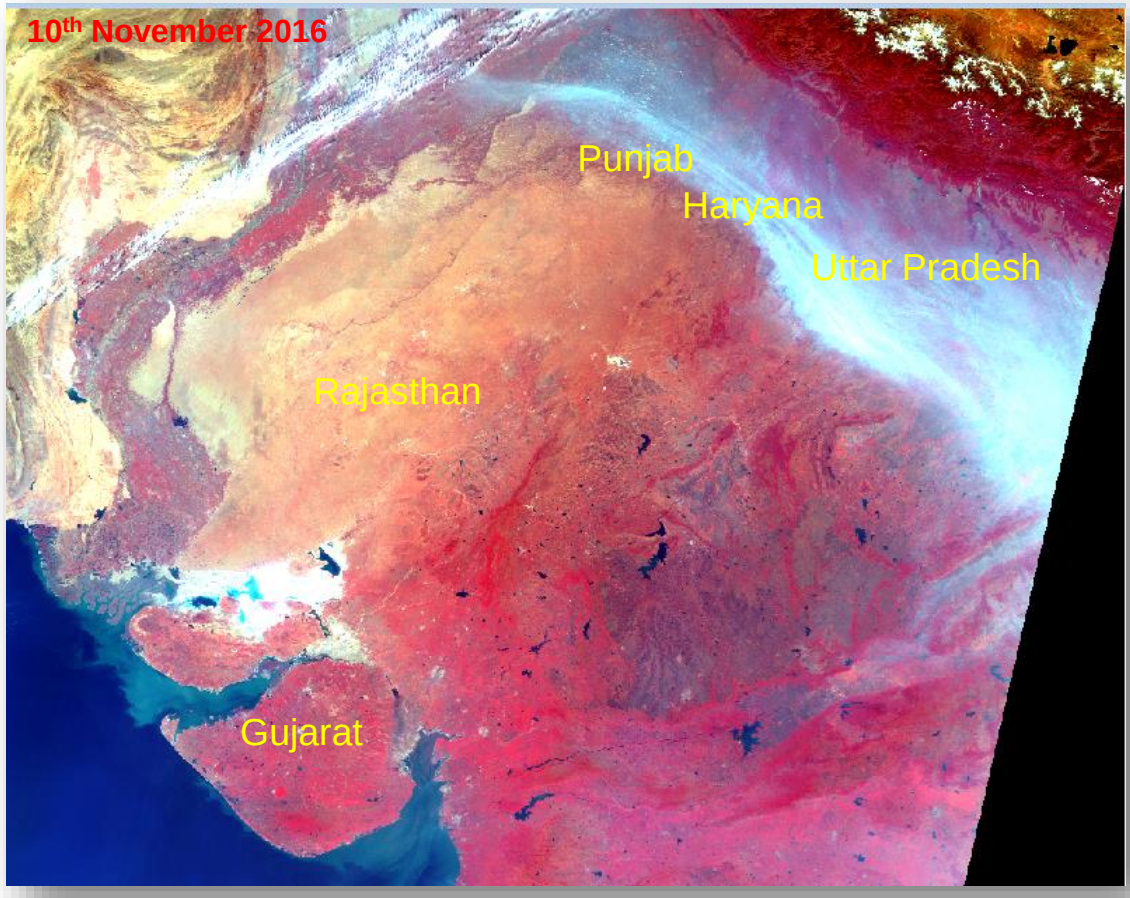


Natural hazards and Disasters

Winter Haze & Fog

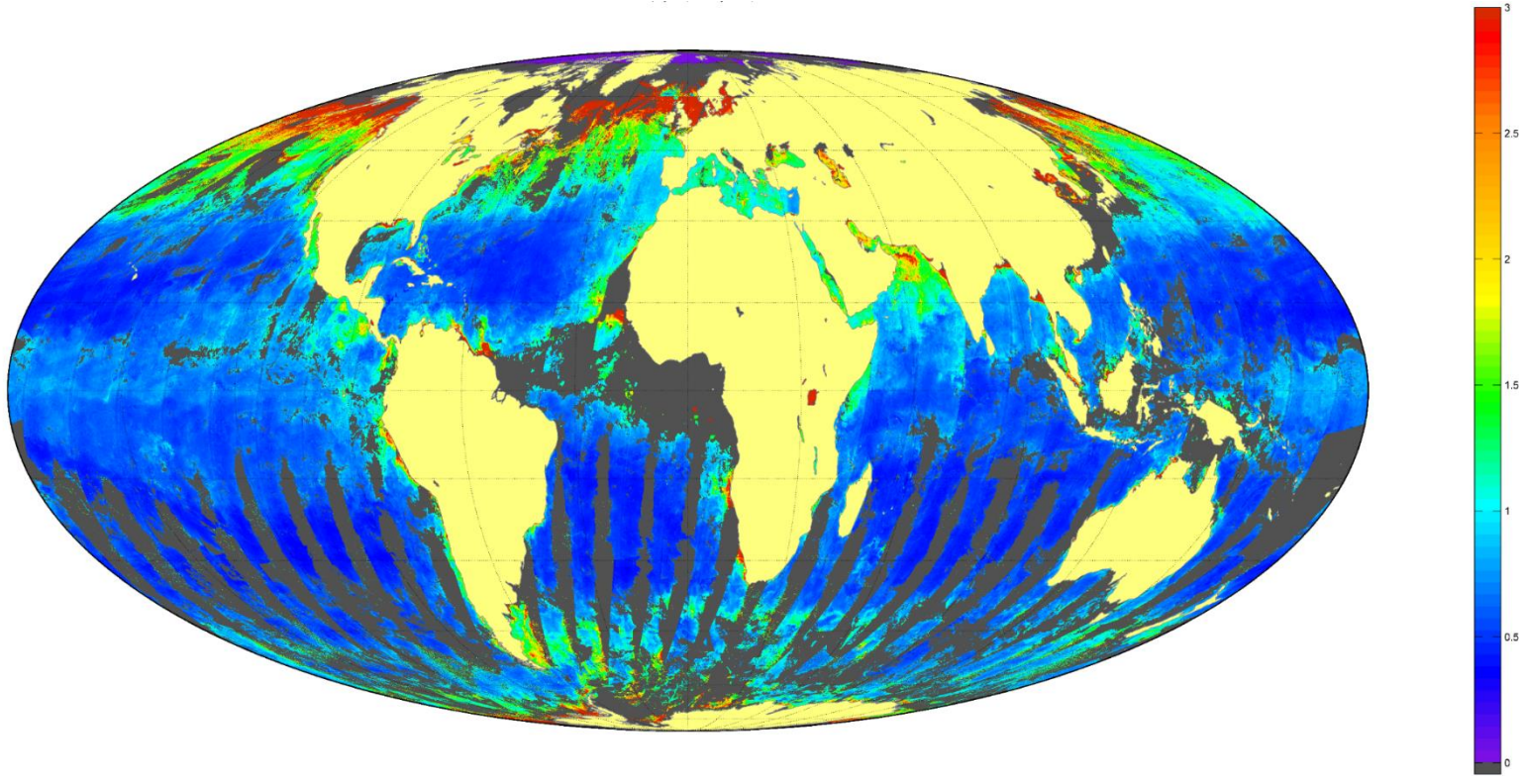
SMOG

Winter Smog is a mixture of smoke and fog. Air pollution in form of soot particulates from smoke, sulphur dioxide and other components derived from vehicular emission from internal combustion engines and industrial fumes react in the atmosphere with sunlight to form secondary pollutants. During Winters, weather is generally foggy and during low winds pollution becames trapped and could build up to sometimes dangerous levels within a town or city.



OCM-2 captured this image of smog prevailing in the northern states of the country. The average daily temperature ranged between 18-22^0 C. Low night time temperatures cause fog in these areas. Few events of crop residue burning along with vehicular emissions cause heavy smog, seen as white coplanar dense plume.

Global distribution of Chlorophyll-*a* derived from OCEANSAT-2 OCM



OCM-2 Chlorophyll-a (February 2012)