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NDVI Generation of Chlorophyll from OCM Data for The Indian Ocean Region Using Multispectral Images.

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ABSTRACT

This research work describes the way to generate the Normalized Difference Vegetation Index of Ocean Colour Monitor (OCM) data and Vegetation of the Indian Ocean. Vegetation index are directly associated with the presence of Chlorophyll. In general, using the vegetation index, it is always possible to estimate Biomass value. In order to carry out the process, an estimation of biomass is carried out with respect to percentage of vegetation coverage obtained from Ocean Colour Monitor (OCM) images extracted from a multispectral imaging system. Chlorophyll yield was estimated using reflectance-based NDVI generation with the help of multispectral imaging system. Measurements of Wavelengths, Intensity of visible and Near-Infrared light reflected by the land backup into the space are determined to enumerate the concentrations of green vegetation around the earth. The analysis of these parameters with respect to oceanic data carried from multispectral images will be used in identifying fishing areas in the ocean.
Keywords: OCM, NDVI, Chlorophyll, OceanSat-2, Biomass, Remote Sensing.

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INTRODUCTION

The Normalized Difference Vegetation Index is a graphical form of indicator helps to study about the remote sensing measurements, usually used to observe green vegetation. NDVI uses the visible and near-infrared bands of the electro-magnetic spectrum to analyze measurements and assess the information of green vegetation. Different colors of visible and near-infrared sunlight reflected by the green plants are used to conclude the density of green ratio of land and ocean. Chlorophyll and pigment in plant leaves are heavily absorbs visible light to carry out process called photosynthesis. The basic cell structure of the green leaves reflects near-infrared lights. The presence of more leaves or phytoplankton indicates the severity of wavelength. Normally, light affected Normalized Difference Vegetation Index is calculated from these visible and near-infrared light reflected by the vegetation. Healthy growth vegetations absorb most of the visible lights that hits on it. It reflects a huge portion of the near-infrared light. Sparse vegetations are reflects more visible lights and less near-infrared lights. These reflected sunlight enters into ocean, gets absorbed to scatter and reflect by the phytoplankton and other related material form the color of water surface.

Related Works:

Different techniques had been used to find chlorophyll concentrations in the literature. Analyze about the NDVI using Meteosat SEVIRI sensor presented a results of NDVI, SEVIRI (Spinning Enhanced Visible and Infrared Imager) sensor detects radiation in twelve spectral bands in which two are exactly suited for vegetation studies. Time series of SEVIRI NDVI plotted with MODIS and Aqua NDVI for comparison [15]. NDVI generation from these data types explanations missed and also spectral channels information. Vegetation rendering using NDVI explains about terrain rendering and texture splatting. To increase rendering performance many approaches had been used like point, volume, billboard based approaches. NDVI corresponds to trees and bushes and displayed using described billboard approach [16]. This method reduced visible trees depend on view points and accelerate cached geometry.

Topographic effects used to find sensitivity of the EVI and NDVI, EVI and NDVI are both vegetation indices to provide spatial and temporal information. The Vegetation Index derived from more than two bands with respect to special characteristics of vegetation. EVI used to reduce atmospheric and soil related information concurrently. Soil factor in the EVI is slightly difference with NDVI, topography information may affect if size of the pixel increased [12, 17].

Vegetation change monitoring done with time series data of NDVI from Landsat TM satellite images. NDVI is derived from TM images provides information about the vegetation related data for particular area, the analysis of NDVI and annual precipitation used to understand about changes in vegetation. NDVI statistically related with the variations in the annual precipitation [18]. Comparative study of vegetation indices helps to get more absolute change of vegetation information for the particular study area. Image segmentation and binary change detection model using threshold, these are the key modules of forest cover change detection. These are evaluated by temporal QuickBird data set, segmentation used to form the objects in image and change maps attained from NDVI. NDVI and spectral value taken as input data for change detection. The above said data set proved the efficiency of forest cover change detection [11, 19]. Unsupervised approach provides analysis of the different time series image.

Vegetation change method includes the arrangement of time series data, vegetation variation and gradation analysis. Vegetation cover in mining area inclined by the consumption of mineral resources. Changing trends analyzed by NDVI yearly data and variable of linear regression used to simulate trend of vegetation in study area [20]. The gradient of line displays the changing trends of vegetation. NDVI time series data arranged to get the vegetation information in mining area. NDVI remote sensing method presented to monitor crop growth monitoring in agriculture. Vegetation indices are parameters which transfer information of surface vegetation properties. The NDVI enhancement identifies the capacity of soil background and NDVI values increased with respect to growth of crops. NDVI slowly decrease at certain growth of crops [21]. Crop growth monitoring guarantied national food security and agriculture development.

Pumping system was used to find chlorophyll in the beginning. Sensors mounted on the pump frame were used to measure temperature and pressure. A light meter LICOR consisting of a flat plat collector measuring radiation. Small portion of the pump outflow was diverted to a Turner fluorometer which measured chlorophyll fluorescence. This experimental design afforded higher vertical resolution ~ 3 to 5m, since the samples were incubated at the same light level as that of the collection depth. Continuous profiles of irradiance and chlorophyll were sampled with the pump sampler system. The validity of comparing production measurements based on solar and artificial light-incubations was examined. The quantum energy spectra were measured with a quanta spectrometer. Thus the experiment depends on artificial light source energy and other high end equipment's. Photosynthetic created by some artificial source. Pigment calculation is dependent on the light absorbing complex [4, 7].

Non-Sea WiFs wavelengths were not consistently present in the global data set to develop chlorophyll algorithms. Interpolated values were measured the values present in the global data set. This scheme was used to scale the chlorophyll concentration. A pattern common to the plots is progressive increase in dispersion with increasing chlorophyll concentration and decreasing band ratio. In case of ocean color data merging, one issue will be there is how data from satellite sensors having different center band wavelengths can be merged to generate seamless maps of chlorophyll distribution. Among several possible approaches, one is to develop internally consistent, sensor-specific variations of empirical chlorophyll algorithms tuned to the same data set [3]. But this version needs significant improvement in size, quality and bio optical diversity. Clear water regions and optimal sampling times may easily identify and targeted for special experiments. Influence on phytoplankton on the color of sea water has been studied for many decades. It is well defined that chlorophyll a, the primary photosynthetic pigment in phytoplankton absorbs more blue and red light than green. The Coastal Zone Color Scanner ocean color data profoundly used to understand the global distribution of phytoplankton. CZCS has ocean color sensors, but these sensors have less bands and lower precision. It was used to estimate chlorophyll pigment concentrations from satellite radiance data [3]. There is no improvement in accuracy and phytoplankton biomass assessments. Anyway still it estimates chlorophyll concentration from the ocean radiance data. To evaluate the performance of chlorophyll algorithms to be used at global scale with SeaWiFs data. This Evaluation encompasses the widest possible chlorophyll concentration range.

Sample plots were selected in different altitudes with some trees. All trees considered in sample plots though specific signs and were installed on trees. At the end of the year, the collected information was classified and the date of commencement and completion of the appearance. Another method for quantifying phonological development is measuring the chlorophyll content. The chlorophyll meter is broadly used in agriculture to control nitrogen content of crop leaf blade [8]. Different leaves have different chlorophyll content. The chlorophyll content varies depend on different locations. But the chlorophyll meter won't give accurate value for different climate. The climate will change chlorophyll concentration on trees. It may vary depend on different climate conditions.

Generally, the Electromagnetic Radiation is classified by wavelength into radio wave, micro wave, infrared, ultraviolet rays, X-rays, Gamma rays and the visible region that we can see as light [1, 9]. All the wavelengths are depending on Electromagnetic Radiation. High frequencies have short wavelengths and low frequencies have very long wavelengths [13]. Actually Electromagnetic Radiation interact with single atoms and molecules, the behavior of the electromagnetic radiation is depending on amount of energy per quantum it carries. Electromagnetic radiation in the visible light area consists of photos, that are the inferior end of the energies that are competent of causing electronic excitation within molecules [2, 6]. It may lead to changes in the bonding among the molecules. Within the visible light spectrum, the lower end is invisible to the humans and other living things because this light spectrum has low visible objects, the photons of a low visible light no longer have sufficient individual energy to cause a permanent molecular change in the visual molecule retinal in the human retina [10]. Beyond the range of visible light, UV light becomes invisible to human beings mostly due to its absorbed by the tissues of the human eye and in particular lenses [3, 5]. But the insects and shrimps are able to directly sense Ultraviolet visually [14].

MATERIALS AND METHODS

This research work used a Oceansat-2 Ocean Colour Monitor (OCM) data for chlorophyll evaluation around Indian ocean. This data is retrieved from Oceansat-2 satellite of ISRO. Oceansat-2 is an Indian Satellite, which is designed to provide service continuity for operational users of the Ocean Colour Monitor instrument on Oceansat-1. The major objectives of OceanSat-2 are to study surface winds and ocean surface stratum, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and balanced sediments in the water. It is also improving the possible of applications in other areas. Oceansat-2 is ISRO's second in the series of Indian Remote Sensing satellites committed to ocean research, and it will provide continuity to the applications of Oceansat-1 (launched in 1999). Oceansat-2 will carry three payloads including an Ocean Colour Monitor (OCM-2), similar to the device carried on Oceansat-1. Data from all instruments will be made available to the global scientific community after the post-launch sensor characterization. HDF data contains metadata of Satellite observed information, which is shown in figure 1 below.

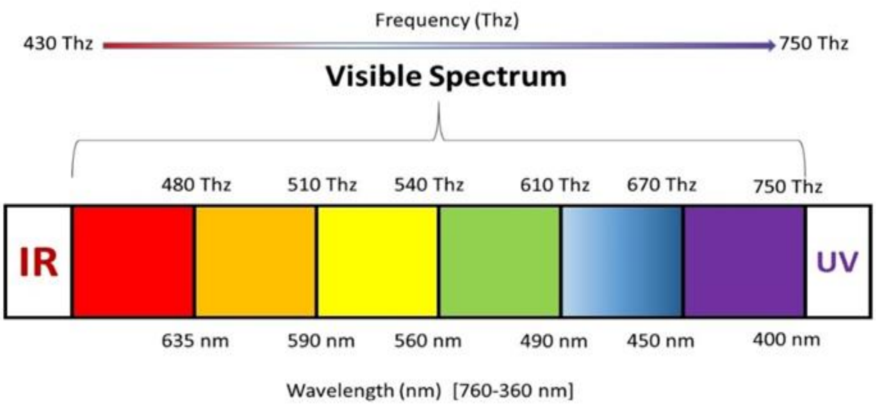
Fig 1: Metadata of HDF Data

	1224	1225	1226	1227
3067	0.0122691...	0.0159521...	0.0074410...	0.0075263...
3068	0.01743218	0.0111326...	0.0231985...	0.0074937...
3069	0.0082377...	0.0180460...	0.0104746...	0.0074286...
3070	0.0190354...	0.0136574...	0.0212312...	0.0080373...
3071	0.0132480...	0.0144217...	0.0088218...	0.0074285...
3072	0.0088558...	0.0194313...	0.0074083...	0.0074285...
3073	0.0079487...	0.0149362...	0.0073429...	0.00742856
3074	0.0122443...	0.0195148...	0.00734291	0.0073959...
3075	0.0102215...	0.0178225...	0.0072775...	0.0072982...
3076	0.0165702...	0.0073229...	0.0120328...	0.0073633...
3077	0.0073229...	0.0074813...	0.0073428...	0.0073633...
3078	0.0072578...	0.0072904...	0.0086153...	0.0073633...
3079	0.0072252...	0.0073879...	0.0111671...	0.0073959...
3080	0.0077464...	0.0115479...	0.0079638...	0.0095787...
3081	0.0746623...	0.0110279...	0.0149911...	0.0091226...
3082	0.0069319...	0.0126528...	0.0	0.22017834

OceanSat-2 Data:

The main objectives of Oceansat-2 are to gather systematic data for oceanographic, coastal and atmospheric applications. Next objectives of OceanSat-2 are to study about surface winds and ocean surface strata, Observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water. Chlorophyll concentration change in different time and weather conditions, then NDVI will change based on different conditions. Different band classifications and its properties explained below in figure 2.

Fig 2: Detailed information of spectral bands



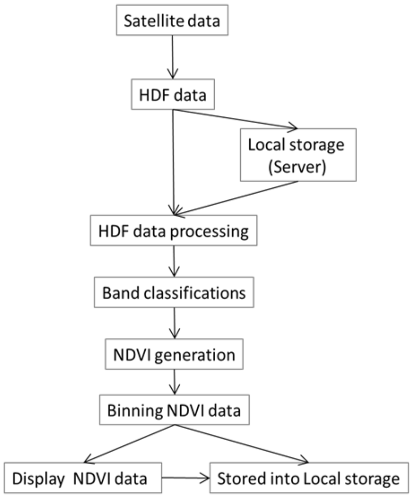
The major applications of data from OceanSat-2 satellite is identification of potential fishing zones, sea state forecasting, coastal zone studies and inputs for weather forecasting and climatic studies. Ocean Colour Monitor (OCM) is 8-band multi-spectral camera operating in the visible – near IR spectral range. This camera provides an instantaneous geometric field of view of 360 meter and a swath of 1420 km. Ocean Colour Monitor can be titled up to +20 degree along track.

The absorption of microscopic marine plants, called phytoplankton, can be resulting from satellite observation and quantification of ocean color. This is due to the fact that the color in most of the world's oceans in the visible light region, (wavelengths of 400-700 nm) varies with the concentration of chlorophyll and other plant pigments present in the water, i.e., the more phytoplankton present, the greater the concentration of plant pigments and the greener the water. Ocean color data have been deemed important by the oceanographic community for the study of ocean primary production and global bio geochemistry.

Methodology:

Method to generate Normalized Difference Vegetation Index of Chlorophyll from OCM-2 data is given below in figure 3.

Fig 3: Framework of NDVI generation methodology



HDF Data:

These Oceansat-2 data converted in HDF file format. HDF is the abbreviation of Hierarchical Data format, it has set of file formats and libraries designed to purpose of store and organizing the large amounts of numerical data. There are many tools available to access this HDF file format. HDF file format designed by the National Center for Supercomputing Applications (NCSA) to help the users in the storage and manipulation of scientific data among different operating systems and machines. HDF can support different variety of data types like data arrays, tables, test and different types of raster images and their associated color fields. The reasons why we choose HDF are, HDF makes it achievable for programs to obtain information about the data from the data file itself, it is a platform independent file format and data models can easily added to HDF by the user.

HDF Data Processing:

OCM-2 satellite data converted into HDF file format for the purpose of durability and platform independent. Those HDF files can be downloaded from the ISRO websites. It contains metadata and geographical data's which is obtained by the satellites. Downloaded HDF data's consists of latitude and longitude information's, sensed objects by the satellites and other earth related information.

Some processes are there to convert the HDF file format data to computer supported image file formats. First the HDF file taken as input in Image processing software. Then the software can easily read Meta data of the HDF file, those metadata then converted into binary objects. The image can be obtained from the HDF file with respect to lat long information's and other Earth observed binary files. Usually HDF files have metadata within itself, maximum which is in the form of binary values. This is then converted into images according to binary values with respect to metadata.

Band Classification:

Algorithm for Band Classification:

Read HDF data
Pull the bands from the HDF
Band 1, Band2, Band 3,. . Band n
If band 1 or band 2 or band 3= 'Geospatial data'
Store Geospatial data in different names
Else leave the HDF

Bands are classified based on the colors. It depends on sensors also. In this study we are using HDF data for NDVI chlorophyll data, within the HDF data there are many attributes and datasets are available with respect to HDF data. HDF data can have a Longitude and Latitudinal information with it. Every dataset denotes particular object of the satellite imagery. Dataset can have band data of satellite images. This band information is used to find the NDVI of chlorophyll data from the HDF data. For the NDVI generation we need only three bands, first we have to separate these bands from the HDF data, then those band data are applied and initiated in formula of NDVI generation.

NDVI Generation:

The Normalized Difference Vegetation Index (NDVI) is a uncomplicated graphical indicator that can be used to study of remote sensing measurements, normally but not automatically from a space platform, and assess whether the target being observed contains live green vegetation or not. Table 1 shows wavelength of chlorophylls and its photosynthesis rate percentage.

Table 1: Chlorophyll absorption and Photosynthesis rate for different wavelengths

Wavelength (nm)	Absorption (%)			Photosynthesis Rate (%)
	CHLOROPHYLL a	CHLOROPHYLL b	CAROTENOIDS	
400	30	0	22	80
420	40	3	28	86
440	43	18	24	96
460	68	38	60	90
480	5	82	48	85
500	0	62	58	80
520	2	30	45	53
540	3	8	20	38
560	5	0	0	26
580	6	0	0	30
600	8	0	0	40
620	10	0	0	45
640	8	5	0	80
660	50	28	0	74
680	15	3	0	93
700	0	0	0	40
720	0	0	0	18
740	0	0	0	8
760	0	0	0	2

The NDVI is calculated from these individual measurements as follows:

$$NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$$

$$NDVI = \frac{X_i}{Y_j}$$

where VIS and NIR stand for the spectral reflectance measurements acquired in the visible (red) and near-infrared regions. NDVI generation algorithm is represented as below.

Read the Geospatial data from the different Bands in HDF
Let Band 3 Geospatial data = NIR
Let Band 2 Geospatial data = VIS
Calculate NDVI from NIR and VIS
Let X_i = NIR – VIS
Let Y_j= NIR + VIS
Let NDVI = X_i / Y_j
Show NDVI image

These spectral reflectance's are themselves ratios of the reflected over the incoming radiation in each spectral band individually; hence they take on values between 0.0 and 1.0. By design, the NDVI itself thus varies between -1.0 and +1.0. It should be noted that NDVI is functionally, but not linearly, equivalent to the simple infrared/red ratio (NIR/VIS). Table 2 indicates concentration of chlorophyll content and its properties based on bandwidth values.

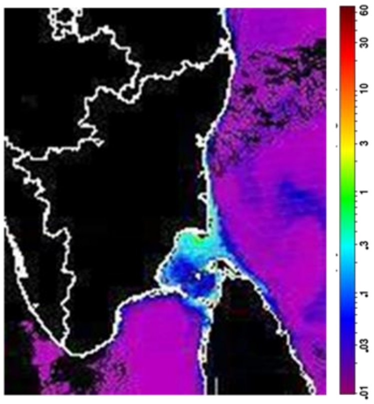
Table 2: Colours and Bandwidths of OCM Chrlophyll data

Band No.	Band Width Values and its Colour	Colours	Properties
1	433-453 nm (blue)		chlorophyll absorption
2	510-530 nm (green)		chlorophyll concentration
3	540-560 nm (yellow)		Gelbstoffe concentration
4	660-680 nm (red)		aerosol absorption
5	700-800 nm (far red)		land and cloud detection
6	10.5-12.5 microns (infra-red)	surface temperature	Nil

The advantage of NDVI over a simple infrared/red ratio is therefore generally limited to any possible linearity of its functional relationship with vegetation properties (e.g. biomass). The simple ratio (unlike NDVI) is always positive, which may have practical advantages, but it also has a mathematically infinite range (0 to infinity), which can be a practical disadvantage as compared to NDVI. Also in this regard, note that the VIS term in the numerator of NDVI only scales the result, thereby creating negative values. NDVI is functionally and linearly equivalent to the ratio NIR / (NIR+VIS), which ranges from 0 to 1 and is thus never negative limitless in range.

But the most important concept in the understanding of the NDVI algebraic formula is that, despite its name, it is a transformation of a spectral ratio (NIR/VIS), and it has no functional relationship to a spectral difference (NIR-VIS). In general, if there is much more reflected radiation in near-infrared wavelengths than in visible wavelengths, then the vegetation in that pixel is likely to be dense and may contain some type of forest. Subsequent work has shown that the NDVI is directly related to the photosynthetic capacity and hence energy absorption of plant canopies. Here the coastal area of Chennai taken for the research work. This area evaluated for the chlorophyll concentration at different levels and different time periods. Chlorophyll concentration frequently changed based on the climate and sea temperature. Figure of evaluation result shown below in figure 4.

Fig 4: Chlorophyll concentration from OCM-2 HDF-4 data around Chennai coastal place of India



Chlorophyll concentration levels at different time periods noted and evaluated for the research work. This evaluation helps to identify the pigments on particular time interval. Chlorophyll concentration widely spread for a particular time period, on that time majority living organisms can get proper foods for their growth. This research helps to fishermen to calculate which time period is best for fishing, as well as which area is best for fishing. So they can easily get understand about sea culture. Analyzed report of chlorophyll concentration among different time periods are evaluated and shown the report as table format in table 3. The graphical form of the analyzed report is shown in figure 5.

Table 3: Analyzed report of chlorophyll concentration among different time periods

Feb, Mar, April		**May, Jun, July**		**Aug, Sep, Oct**		**Nov, Dec, Jan**	
Distance Offshore (km)	Chlorophyll a (mg/m3)	Distance Offshore (km)	Chlorophyll a (mg/m3)	Distance Offshore (km)	Chlorophyll a (mg/m3)	Distance Offshore (km)	Chlorophyll a (mg/m3)
280	$10^{-0.3}$	280	$10^{-0.9}$	280	$10^{-0.8}$	280	$10^{-0.7}$
260	$10^{-0.4}$	260	$10^{-0.8}$	260	$10^{-0.7}$	260	$10^{-0.5}$
240	$10^{-0.5}$	240	$10^{-0.9}$	240	$10^{-0.6}$	240	$10^{-0.6}$
220	$10^{-0.5}$	220	10^{-1}	220	$10^{-0.6}$	220	$10^{-0.5}$
180	$10^{-0.1}$	180	10^{-1}	180	$10^{-0.7}$	180	$10^{-0.4}$
160	$10^{-0.1}$	160	$10^{-0.9}$	160	$10^{-0.5}$	160	10^{0}
140	$10^{-0.2}$	140	$10^{-0.9}$	140	$10^{-0.3}$	140	$10^{-0.1}$
120	$10^{-0.3}$	120	$10^{0.5}$	120	$10^{-0.2}$	120	$10^{-0.1}$
80	$10^{-0.2}$	80	10^{1}	80	$10^{0.5}$	80	10^{0}
60	$10^{0.2}$	60	$10^{0.6}$	60	$10^{0.7}$	60	$10^{-0.6}$
40	$10^{0.3}$	40	$10^{0.3}$	40	$10^{0.6}$	40	$10^{0.1}$
20	$10^{0.5}$	20	$10^{0.8}$	20	$10^{0.9}$	20	$10^{0.8}$

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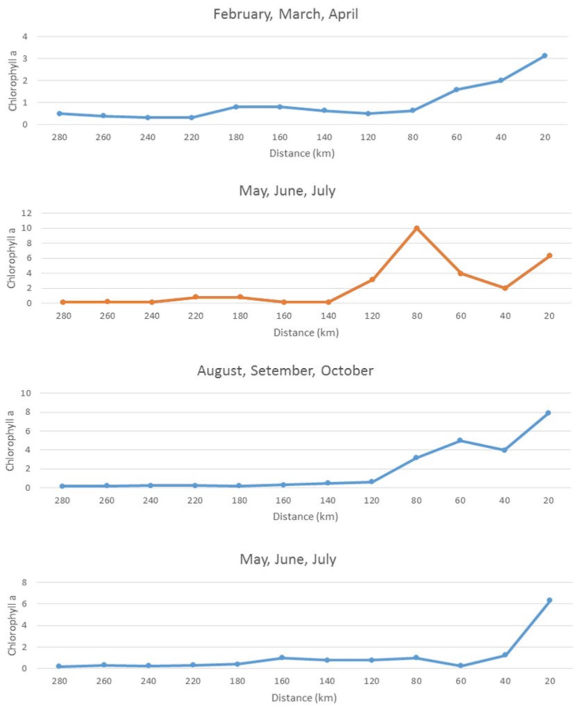
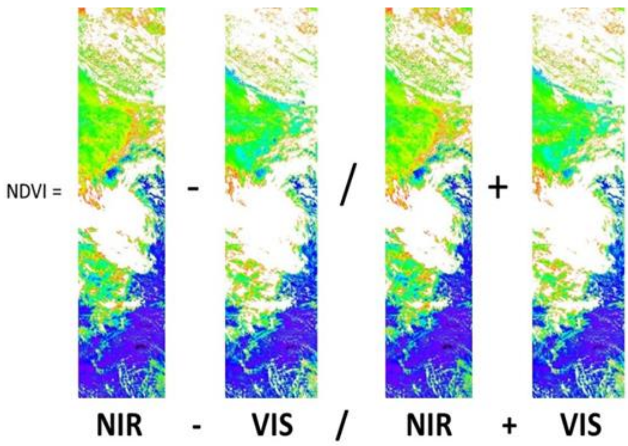
Fig 5: Chlorophyll concentration levels at different time periods with distance offshore



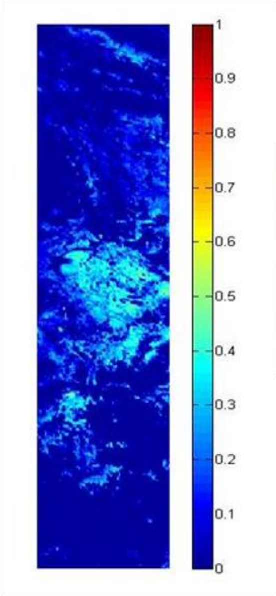
The Normalized Difference Vegetation Index is a single band image derived from mathematical combinations of bands which measure the response of vegetation very differently. This image is a measure of relative amounts of green vegetation. The NDVI is computed as: (Band_3 - Band_2)/ (Band_3 + Band_2). The NDVI shows the absolute large quantity of actively photosynthesizing vegetation. In other words, it shows how healthy the vegetation is growing on the particular field. Band classification from OCM-2 data is given below in figure 6.

Fig 6: Band classification and NDVI generation from NIR, VIS



Below figure 7 shows color mapped image of NDVI from band classification along with image info results.

Fig 7: Sample input and output for pixel intensity filter



NDVI color mapped (JET)

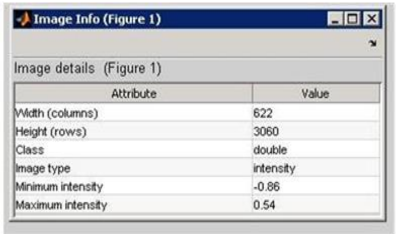


Image Info (Figure 1)

Image details (Figure 1)

Attribute	Value
Width (columns)	622
Height (rows)	3060
Class	double
Image type	intensity
Minimum intensity	-0.86
Maximum intensity	0.54

Image Info

Binning of NDVI :

Algorithm for Binning the NDVI image:

Read the NDVI image
Check NDVI resolution i
If resolution i≥Large
    Resize the resolution i as low resolution
    Check image quality after resizing
    If Image quality i% < original image quality
        Enlarge the image
    Else
        Store the image
Else
    Show the original NDVI image

After the NDVI generation the produced image is undergone to binning for resize the satellite image. Binned NDVI image result shown below in figure 8.

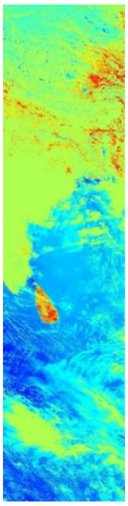


Fig 8: NDVI image from OCM HDF data after Binning operation

This binning is used to keep the quality of the resultant satellite image with low pixel size. With the help of this binning technique the storage capacity and generation process can be very easy and faster.

RESULTS AND DISSCUSSION

Hence, from the framework of Chlorophyll NDVI generation, Oceansat-2 satellites observe the chlorophyll concentrations on a sea and take it as data. That data is converted in the Hierarchical Data Format (HDF), then this HDF data can store into local data server or directly it can be take it for NDVI generation. Those stored HDF data's processed for band segregation, classified bands are taken for NDVI generation. Generated NDVI image data undergone with binning process. This is used to reduce the data size and keep the original format of the generated image. Then it goes to display section and stored into a local storage.

Binning technique used here for the better visualization of NDVI generated images. It helps to decrease the resolution without damaging the image quality. Comparing with other research works they won't apply and introduced the technique of Binning. One more new thing in this research work is clear classification of bands and how those bands are used for evaluation of different vegetation indices.

CONCLUSION

The NDVI data acquired using the OCM data and multispectral imaging system was sensitive to find the changes in plant chlorophyll on ocean data. NDVI generation technique is same for both OceanSat and Landsat data. This study is to find chlorophyll concentrations and growth of phytoplankton plants in water. This is done by the help of OceanSat satellite data of OCM data (Indian Satellite). Here everything is explained about chlorophyll and Satellite measurements of Ocean colors and its respective things. Chlorophyll concentration analysis increases the predicting ability and accuracy of NDVI. This model can be enhanced by incorporating other vegetation indices for better prediction and data analysis.

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