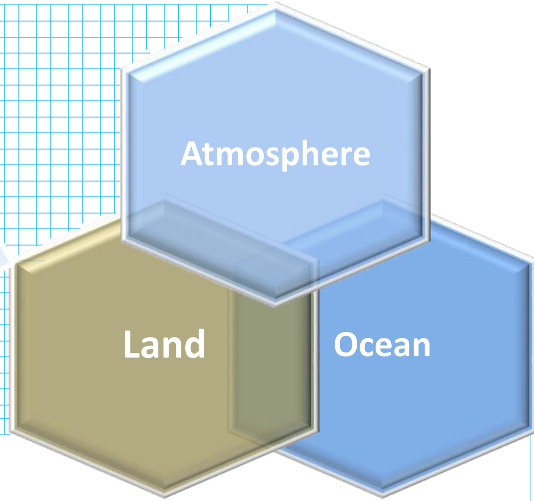
National Information system for Climate and Environment Studies

nrsc



NICES

An Overview

June, 2018

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Shri Santanu Chowdhury
Director

Preface

Observation on Land, Ocean and Atmosphere is essential for understanding the drivers of climate change and its impact on biosphere. Long-term, consistent and accurate database are prerequisite for evaluating the present climate, its temporal change and long-term trend. Climate change is characterized internationally using 'Essential Climate Variables (ECV's) that critically contribute to the characterization of Earth's climate and possible impact. Hence it is imperative to have long-term data inventory on solid earth, ocean and atmosphere on spatial perspective. Realizing the need for national level climate database for climate change impact assessment and mitigation, ISRO has set up the 'National Information system for Climate and Environment Studies (NICES)' at NRSC in 2012 with participation of ISRO and other National Institutions.

Under the purview of NICES several terrestrial, ocean, cryospheric and atmospheric products are being generated using Earth Observation satellite data, some of which are qualified for being ECV's. Each of the product has been generated meticulously following appropriate algorithm and rigorous calibration and validation procedures. Effort has been made to process historical data and regular dissemination through web enabled services. Network of observatories and Atmospheric Science Lab, located at Shadnagar is an integral part of the entire programme for establishing methodologies and in-house experimentation which culminates into accurate product generation.

I am sure that the long-term data base will be extremely useful for climate research studies, mitigation planning and adaptation under Indian perspective. I take this opportunity to congratulate the NICES team for bringing out this comprehensive booklet.

शांतनु Santanu Chowdhury
(Santanu Chowdhury)
Director, NRSC and Chairman, PMC-NICES

June 14, 2018

NICES at a Glance

Setting up of 'National Information system for Climate and Environment Studies' **(NICES)** has evolved through a series of deliberations among various Departments and Ministries culminating in establishing the same at NRSC on 28 September, 2012. NICES envisages realization of national level accurate, consistent and long-term climate database generation, derived from Indian and other Earth Observation (EO) satellites from both polar and geostationary missions for climate change impact assessment and mitigation. In addition, several of the EO-science observations and networks relevant to environmental studies across the nation will form the core database of NICES owned by ISRO/DOS, other Ministries and Institutions.

NICES has been functioning under the overall guidance of NICES-Programme Management Council (PMC) with the composition of Members from inter and intra departmental institutions under the Chairmanship of Director, NRSC and its programmatic activities are periodically reviewed by experts from ISRO/DOS Centers. Accordingly, in the last five years, NICES has built an information base with more than 64 geophysical variables pertaining to land, ocean and atmosphere; the information is being regularly disseminated through a NICES portal developed over Bhuvan, a geo-portal of ISRO.

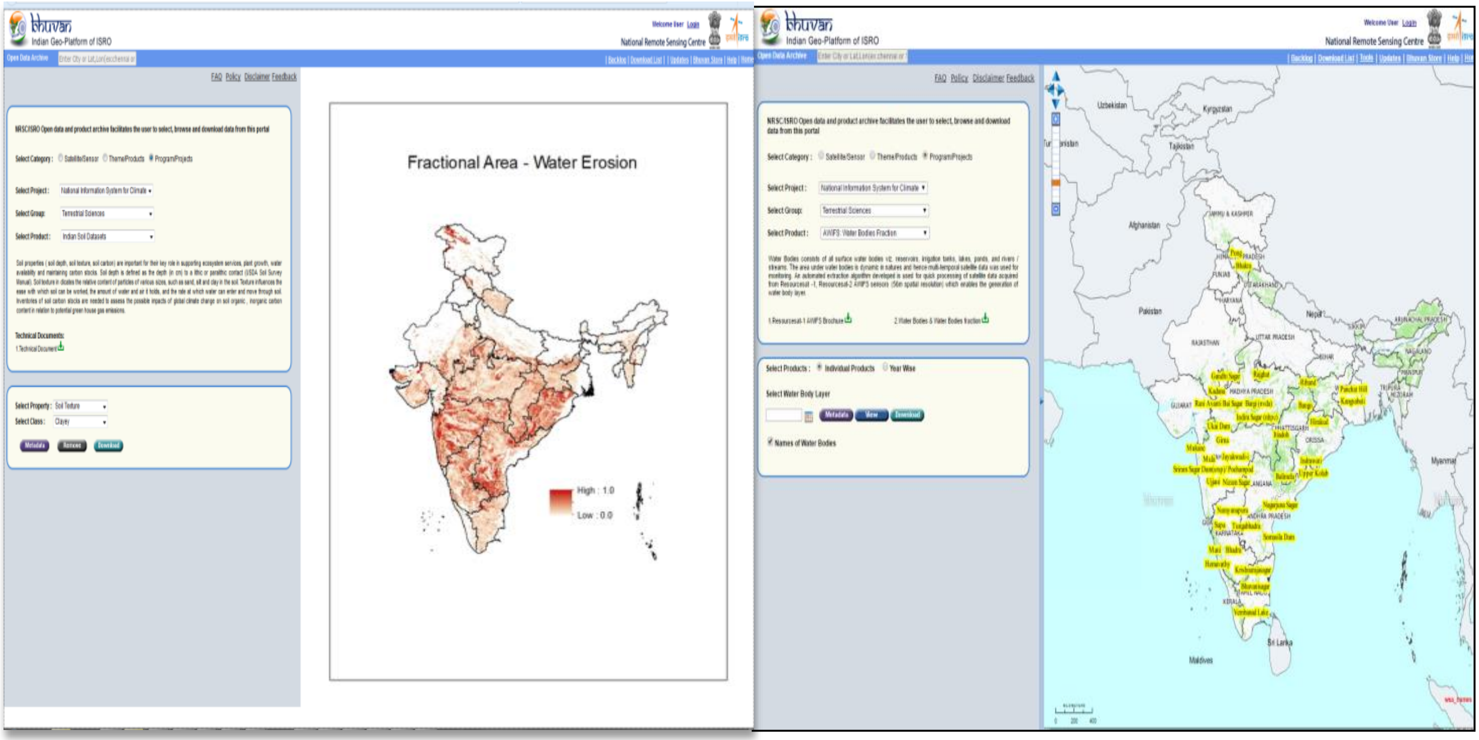
NICES is a multi-institutional effort with the participation of ISRO/DOS Centres and other Departments and national Institutions under various ministries. NICES would strive to strengthen the information base with contributions (in-situ observational and model outputs) from these participating organisations over the years.

NICES Objectives

- To build long term database on climate variables.
- Establish and develop linkages with appropriate observational networks for calibration and validation.
- Acquisition and processing of international missions' data for climate parameters in addition to Indian EO Satellite data to generate a long term data records.
- Establish necessary infrastructure including hardware and software for NICES for climate studies.
- Geophysical parameter retrieval and generation of methodologies for Essential Climate Variables (ECVs) from Indian EO and other international missions.
- Generation of spatial & temporal blended products .
- Develop a science plan for climate change impact assessment, adaptation and mitigation studies with participating organizations.
- Develop an outreach and interaction mechanism for effective dissemination and utilization of NICES information base.
- Capacity building.

NICES Portal

- NICES data products are available through an online portal that is hosted in BHUVAN
- The portal was operational since October 2013 with access to more than 50 products



- More than 45,000 instances of data downloads recorded so
- For more information, visit http://www.nrsc.gov.in/nices

ECV's identified globally as per GCOS 2016 report

ATMOSPHERE

Surface	Upper	Composition
Surface Air Temperature	Air Temperature*	Carbon Dioxide*
Near-Surface Wind speed and direction	Wind speed and direction*	Methane
Water vapour (surface humidity)	Water vapour*	Other long lived Green House Gases (N_2O,CFCs,HCFCs, SF_6 & PFCs)
Surface Air Pressure	Cloud properties*	Ozone*
Surface Precipitation*	Earth Radiation Budget (including Solar Irradiance)*	Aerosols properties*
Surface Radiation Budget		Precursors (supporting aerosols and Ozone ECV's – NO_2,SO_2,HCHO,CO)

OCEAN

Surface	Sub Surface
Sea Surface Temperature*	Temperature
Sea Surface Salinity	Salinity*
Sea Level*	Current
Sea State*	Nutrients
Sea Ice*	Carbon dioxide partial pressure
Surface Current	Sub surface Ocean Acidity
Ocean Color*	Oxygen
Carbon Dioxide Partial Pressure	Tracers
Surface Ocean Acidity	
Phytoplankton	

TERRESTRIAL

River Discharge	Albedo*
Water Use	Land Cover *
Ground Water	Fraction of Absorbed Photosynthetically Active Radiation*
Lakes*	Leaf Area Index*
Snow Cover*	Above Ground Biomass*
Glacier and Ice Caps*	Fire Distribution*
Ice Sheets	Soil Moisture*
Permafrost	Soil Carbon

* *ECV's amenable to Remote Sensing*

Terrestrial Products

S. No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
1	Albedo	Oceansat - 2 / OCM-II	India	Jan 2013 - May 2018	1 Km	Fortnightly	~ 4-6 MB
2	Normalized Difference Vegetation Index (NDVI)						
2.1	NDVI	Oceansat - 2 / OCM-II	Global	Jun 2013 - Mar 2018	8 Km	Monthly	~ 2-3 MB
2.2	NDVI	Oceansat - 2 / OCM-II	India	Jan 2011 - May 2018	1 Km	Fortnightly	~ 4-6 MB
2.3	Filtered NDVI	Oceansat - 2 / OCM-II	India	Jan 2012 - Dec 2017	1 Km	Fortnightly	~ 4-6 MB
3	Surface water bodies fraction	Resourcesat-2,2A/ AWiFS	India	Jan 2014 - Apr 2018	3′x3′	Fortnightly	~ 600 KB
4	Land Use / Land Cover						
4.1	Land Use Land Cover (MM5 Compatible)	Resourcesat -2 / AWiFS	Global	2004-2005 to 2016-2017	30″/2′/5′	Yearly	~10 – 30 MB
4.2	Land Use Land Cover (WRF Compatible)	Resourcesat -2 / AWiFS	Global	2004-2005 to 2016-2017	30 ″/2′/5′	Yearly	~ 2 MB
5	Vegetation Fraction	Oceansat - 2 / OCM-II	India	Jan 2011 - May 2018	1 km	Fortnightly	~ 4-6 MB
6	Soil Carbon Density						
6.1	Mean Organic Soil Carbon density	Resourcesat -2 / AWiFS	India	2014	5 km	Once	~ 40 - 200 KB
6.2	Mean Inorganic Soil Carbon density	Resourcesat -2 / AWiFS	India	2014	5 km	Once	~ 40 - 200 KB
7	Fraction Soil Depth	Resourcesat -2 / AWiFS	India	2000	5 km	Once	~ 40 - 200 KB
8	Fraction Soil Textural Class	Resourcesat -2 / AWiFS	India	2014	5 km	Once	~ 40 - 200 KB

Terrestrial Products

S. No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
9	Land Degradation (3 Layers)						
9.1	Fraction Water Erosion	Resourcesat -2 / LISS-III	India	2005-2006	5 km	10 years	~ 0.5 MB
9.2	Fraction Wind Erosion	Resourcesat -2 / LISS-III	India	2005-2006	5 km	10 years	~ 0.5 MB
9.3	Fraction Salt-affected	Resourcesat -2 / LISS-III	India	2005-2006	5 km	10 years	~ 0.5 MB
10	Surface Soil Moisture	AQUA AMSRE & GCOM-W1 / AMSR2	India	Jul 2002-May 2018	0.25°	2 days	~ 50 KB
11	Fire Regime for India						
11.1	Average Annual Forest Fire Density	AQUA and TERRA/MODIS	India	Jan 2003 – 2016	5 km	Yearly Average	~150 - 250KB
11.2	Standard Deviation of Average Annual Forest Fire Density	AQUA and TERRA/MODIS	India	Jan 2003 – 2016	5 km	Yearly Average	~150 - 250KB
11.3	Length of Fire Period	AQUA and TERRA/MODIS	India	Jan 2003 – 2016	5 km	Yearly Average	~150 - 250KB
12	Forest Cover Fraction	SOI/Landsat-MMS&TM/ Resourcesat -2 / AWiFS	India	1930, 1975, 2013	5 km	Yearly	~450 - 550KB
13	Forest Types	Resourcesat -2 / AWiFS	India	2013	5 Km	Yearly	~30 - 300KB

Contd..

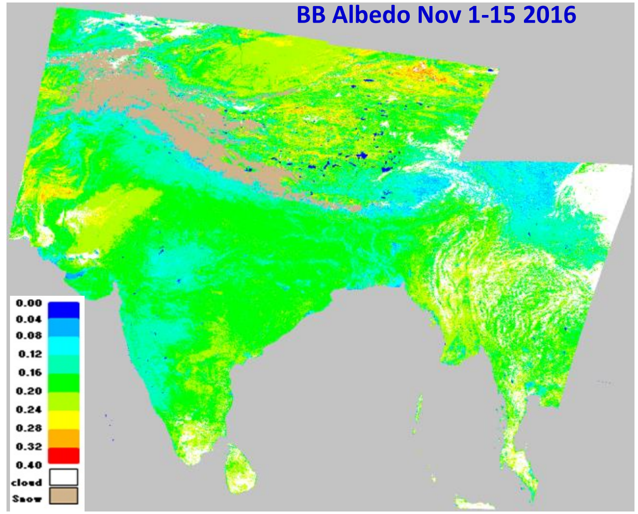
Terrestrial Products

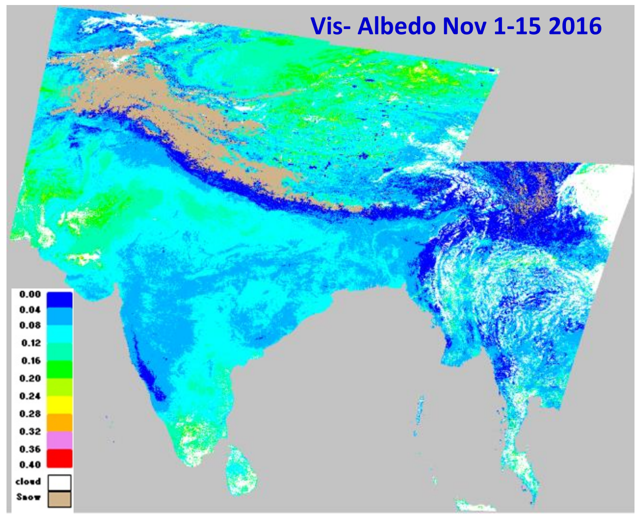
S. No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
14	Net Sown Area						
14.1	Fractional Net Sown Area	Resourcesat -2/ AWiFS	India	2005 - 2016	5 km	Yearly	~ 100 KB
14.2	Fractional Kharif Sown Area	Resourcesat -2/ AWiFS	India	2005 - 2016	5 km	Yearly	~ 20 KB
14.3	Fractional Rabi Sown Area	Resourcesat -2 / AWiFS	India	2005 - 2016	5 km	Yearly	~ 150 KB
14.4	Fractional Fallow Area	Resourcesat -2/ AWiFS	India	2005 - 2016	5 km	Yearly	~ 150 KB
15	Snow Melt and Freeze	Oceansat - 2 / OSCAT	Indian Himalayas	Jan 2000 - Dec 2013	2.225 km	Daily	~ 100 KB
16	Snow Cover Fraction	Resourcesat -2 / AWiFS	Himalayans	Mar 2014 - Apr 2018	3'x3'	Fortnight	~ 20 KB
17	Himalayan Glacial Lakes & Water Bodies	Resourcesat -2 / AWiFS	Himalayan region of Indian river basins	Jun 2011 - Oct 2016	1:250,000 scale	Monthly	~ 150 KB
18	Snow Melt and Freeze	Oceansat - 2 / OSCAT	Antarctica	Jan 2001 - Dec 2017	2.225 km	Daily	~ 100 KB
19	Snow Albedo	Resourcesat -2/ AWiFS	India	Jan 2015 - Apr 2018	250 m	-	~ 3-5 MB
20	Distributed Hydrology Model (VIC)						
20.1	Soil Moisture	Model Derived	India	Jun 2013 - Mar 2018 Jan 1976 - Dec 2015	9′ x 9′	Daily	~150 - 250 KB
20.2	Evapo-transpiration	Model Derived	India	Jun 2013 - Mar 2018 Jan 1976 - Dec 2015	9′ x 9′	Daily	~150 -250 KB
20.3	Surface Runoff	Model Derived	India	Jun 2013 - Mar 2018 Jan 1976 - Dec 2015	9′ x 9′	Daily	~ 150 -250 KB
21	Net Ecosystem Productivity	Model Derived	India	1981- 2014	2‘ x 2'	Monthly	~ 300 MB
22	Net Primary Productivity	Model Derived	India	1981- 2014	2‘ x 2'	Monthly	~ 300 MB

Visible and Broadband Albedo

Albedo is a key parameter that is widely used in land-surface energy balance studies, mid- to long-term weather prediction and global climate change investigation. Surface albedo is the ratio of upwelling radiant energy relative to the down-welling irradiance incident upon a surface. As albedo quantifies the capacity of surface to reflect solar radiation it is one of the main driving factors of the energy balance and interaction between land surface and atmosphere. The most relevant albedo quantity for applications related to the energy budget refers to the total short-wave broad-band interval comprising the visible and near infrared wavelength ranges where the solar down-welling radiation dominates. Satellite remote sensing represents the best way to compile such consistent albedo characterizations.

Oceansat-2 Land surface Albedo Product version 1.0 was derived from the data acquired by Ocean Color Monitor (OCM2) sensor. This is a value added product from OCM2 whose spectral bands are originally designed for ocean parameter retrieval applications. There are two land surface albedo products, namely boardband(BB) (0.3-3 µm) albedo and visible albedo (0.3- 0.7µm), both of which are 15 days composite product.





Snow Albedo for Himalayan Regions

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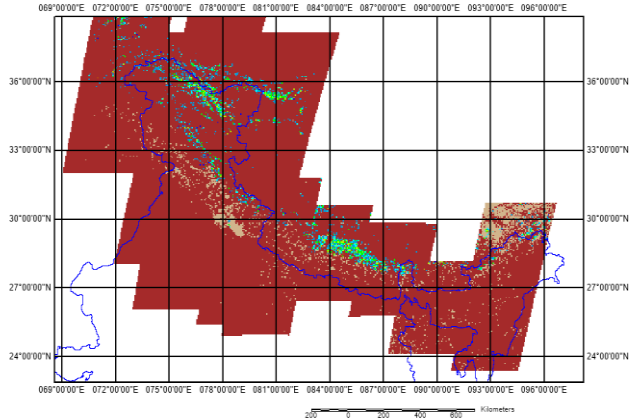
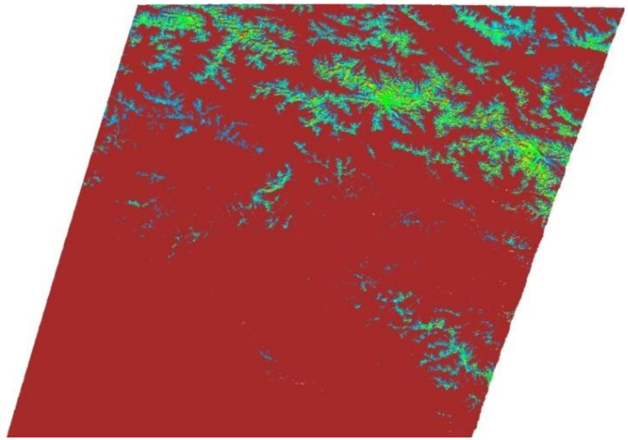
Broadband Snow albedo is an important geophysical parameter. for studies related to weather, climate, and hydrometeorology and so on. Snow has the highest albedo in nature and hence has a significant influence on surface energy budget. The high sensitivity of snow to change in temperature and precipitation makes it a primary indicator of climate change. The Himalayan cryosphere has its importance because the presence of vast snow covers in the Himalaya due to its high elevations. Large areas of the Himalaya are covered by seasonal snowfall during winter which starts ablating with the onset of spring, therefore, the areal extent of snow cover changes significantly which greatly influences the land surface albedos and contributes an important feedback mechanism to global climate system.

Broadband Snow Albedo Products for the Himalayan regions are derived from Resourcesat-2 AWiFS sensor. Broadband snow albedo is computed for solar wavelength region from 0.3 - 3.0µm. The snow bound regions in the AWIFS imagery were delineated using an automatic extraction algorithm. Images were also subjected to topographic corrections which compensates the problem of differential solar illumination. The products are delivered as quadrant scenes at 250m resolution. Four cycles of products are delivered per month.



Snow Albedo mosaic for Cycle1 of Oct'14



Snow Albedo scene for path : 90_43_D_11OCT2016

Albedo Products Specification

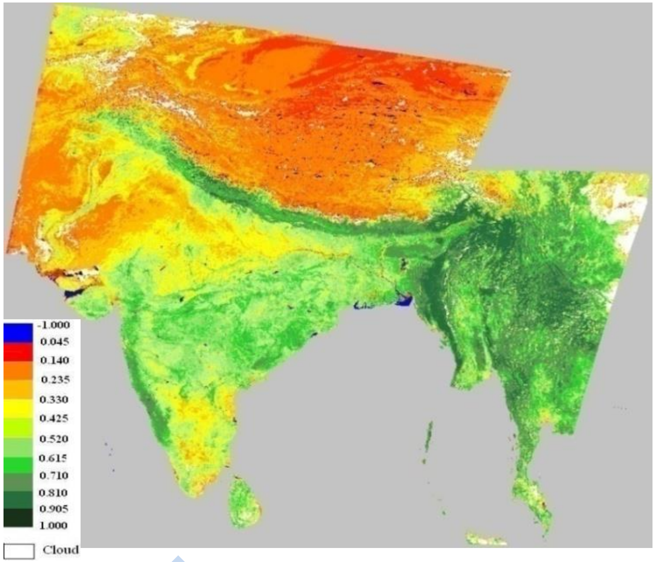
BB & Visible Albedo from OCM

- Image File Format : Geo TIFF
- Projection : Geographic coordinates (Lat., Long.)
- Datum : WGS-84
- Spatial Resolution : 1080m (0.01017 deg)
- Radiometric resolution : 8 bits per pixel
- Product Frequency: Fortnightly
- Correction Level : precision corrected
- Number of bands : 1
- DN-Vis Albedo conversion rule : Vis Albedo = DN/500(in float)
- DN – BB Albedo conversion rule : BB Albedo = DN/500(in float)
- Usable range of DN : 0 – 200
- Masked Label values : 250 (clouds and cloud shadow)
- Permanent Snow region : 240
- Image background : 255

Snow Albedo from RS2-AWiFS

- Image File Format : Geo TIFF
- Projection :Albers equal-area
- Datum : WGS-84
- Spatial Resolution : 250m
- Radiometric resolution : 8 bits per pixel
- Product Frequency: cycle wise(4/month)
- Correction Level : precision corrected
- Number of bands : 1
- DN – BB Albedo conversion rule : BB Albedo = DN/200(in float)
- Usable range of DN : 0 – 200
- Masked Label values : 230 (clouds and cloud shadow)
- Pixels other than cloud and snow : 240
- Pixels with TOA values exceeds 1 : 220
- Image background : 255

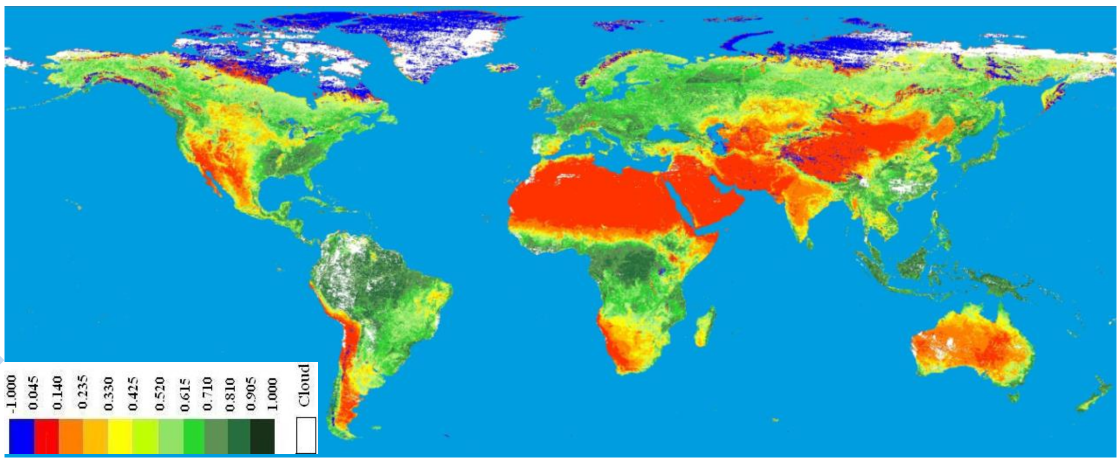
Vegetation Parameter -NDVI



Normalised Difference Vegetation Index (NDVI) is an important variable that represents the crop vigor. Fortnightly OCM2 NDVI/VF products are being generated operationally for Indian subcontient from NRSC since Jan-2012. To maximize the occurrence of clear sky pixels, NDVI products are generated for a 15 day period using maximum NDVI compositing technique. The products are delivered at a spatial resolution of 1080 mts in Geotiff format with geographic projection. Spurious data still remain in case of persistent cloud or other atmospheric effects during the compositing period. Gobal NDVI products are generated from OCM GAC images on a monthly basis.

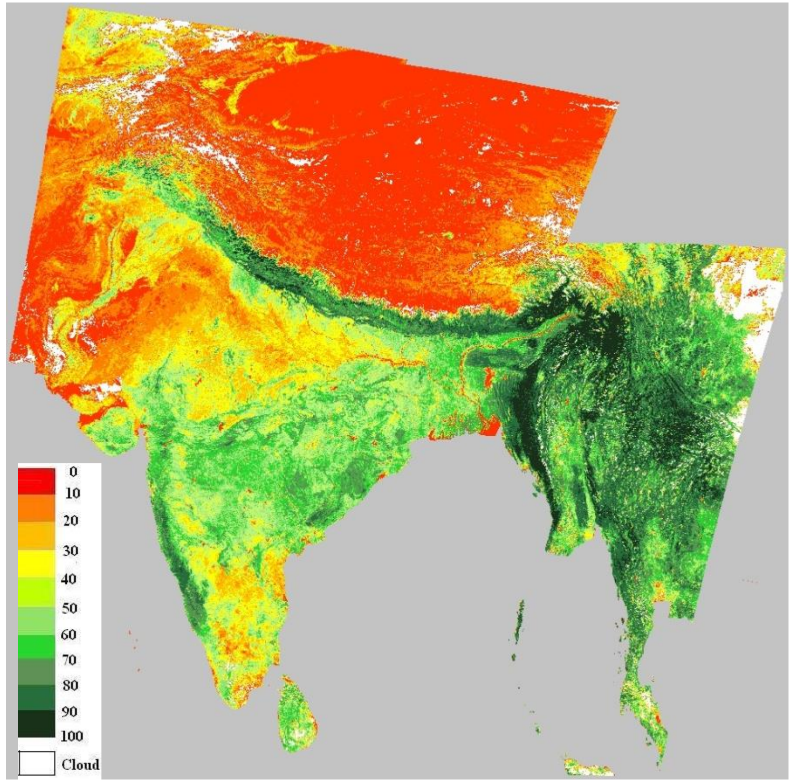
NDVI 1-15 Nov2016

OCM2 NDVI Global Product



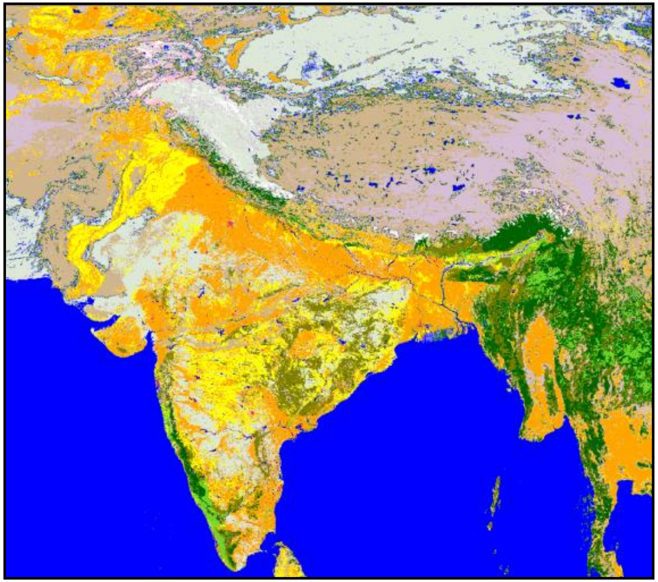
Vegetation Fraction

Vegetation fraction (VF) is defined as the percentage or fraction of occupation of vegetation canopy in a given ground area in vertical projection. It is popularly treated as a comprehensive quantitative index in forest management and vegetation communities to monitor respective land cover conditions. Field measurement approach has been the traditional method of estimating the vegetation fraction; however, the reliability of such measurements for the vegetation fractional coverage is questionable, besides the high cost. To overcome these, satellite based data are strongly pursued recently. Fraction of vegetation are needed as a regular space-time gridded input to evapotranspiration schemes in weather prediction models



Vegetation Fraction 01-15 Nov, 2016

Mesoscale Model Compatible LU/LC at 30", 2' and 5'



30 second AWiFS derived LU/LC

Mesoscale models, in general, are run using the US Geological Survey (USGS) 25 category land use/land (LU/LC) cover data available at different spatial resolution. The USGS data over Indian region suffered two types of errors viz. misclassification of LU/LC and non-availability of up to date satellite based LU/LC data.

To improve the accuracy and to capture inter annual changes better, the LU/LC generated by NRSC using Indian Remote Sensing Satellite (IRS P6) - Advanced Wide Field Sensor (AWiFS) with 56m basic resolution has been scaled to 5, 2 minute and 30 second resolutions which is available at yearly interval.

The Indian region of USGS data was replaced with IRS P6 AWiFS derived data and made compatible to MM5 and WRF mesoscale models.

Thus the resultant product is a global USGS LU/LC data with the Indian region replaced by the information originally derived from AWiFS 56m resolution imagery, for the years 2004-2005 to 2016-2017

Ref- NRSC Document No: NRSC-ECSA-ACSG-OCT-2014-TR-651.

Vegetation Products Specification

NDVI & VF from OCM

Image File Format : Geo TIFF

Projection : Geographic coordinates (Lat., Long.)

Datum : WGS-84

Spatial Resolution : 1080m (0.01017 deg)

Radiometric resolution : 8 bits per pixel

Product Frequency: Fortnightly

Correction Level : precision corrected

Number of bands : 1

DN-NDVI conversion rule : NDVI= DN/200 (in float)

DN – VF conversion rule : VF (%)= DN/2 (in float)

Usable range of DN : 0 – 200

Masked Label values : 240 (clouds ,cloud shadow and pixels with NDVI < 0)

Image background : 255

GAC NDVI from OCM

Image File Format : Geo TIFF

Projection : Geographic coordinates (Lat., Long.)

Datum : WGS-84

Spatial Resolution : ~9 km (0.08333 deg)

Radiometric resolution : 8 bits per pixel

Product Frequency: Monthly

Correction Level : precision corrected

Number of bands : 1

DN-NDVI conversion rule : NDVI= DN/200 (in float)

Usable range of DN : 0 – 200

Masked Label values : 240 (clouds ,cloud shadow and pixels with NDVI < 0)

Image background : 255

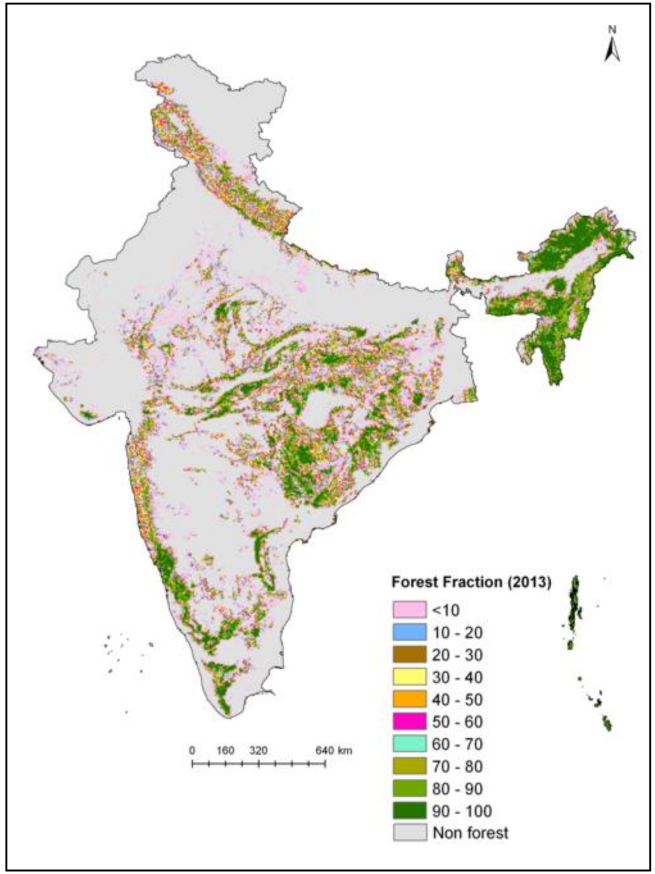
Fractional Forest Cover (5km Grid)

nrsc

There is an increasing concern that tropical deforestation continues to be a major contributor to climate change. The status of global forest cover has large uncertainty owing to the paucity of comprehensive studies related to long term forest cover change. The aim is to prepare a nation-wide multi-date forest cover database which describes and quantifies historical changes in forests of India from 1930 to 2013.

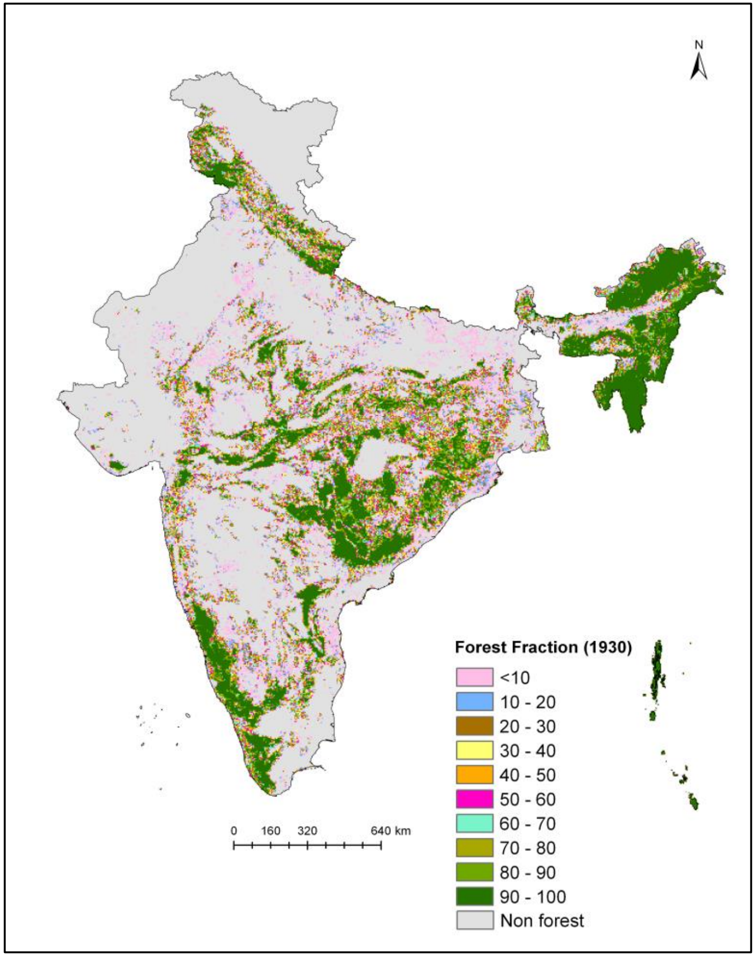
To generate maps of forest cover across India, the topographical maps for 1930's period, Landsat MSS data for 1975 and Resourcesat-2 AWiFS data for 2013 were used. This analysis facilitated the determination of the status of Indian forest cover changes over last eight decades. The results indicated that forests covered an area of 869,012 km^2 in 1930, 653,220 km^2 in 1975 and 625,565 km^2 in 2013. The net loss of forest was 243,447 km^2 (28%) in eight decades.

Information on spatial distribution of natural forests is critical to stop deforestation and degradation. The findings of the study will be useful to prioritize conservation of forest cover at the regional level. It shall also provide a base for future research on the impacts of deforestation on carbon flux and biodiversity.

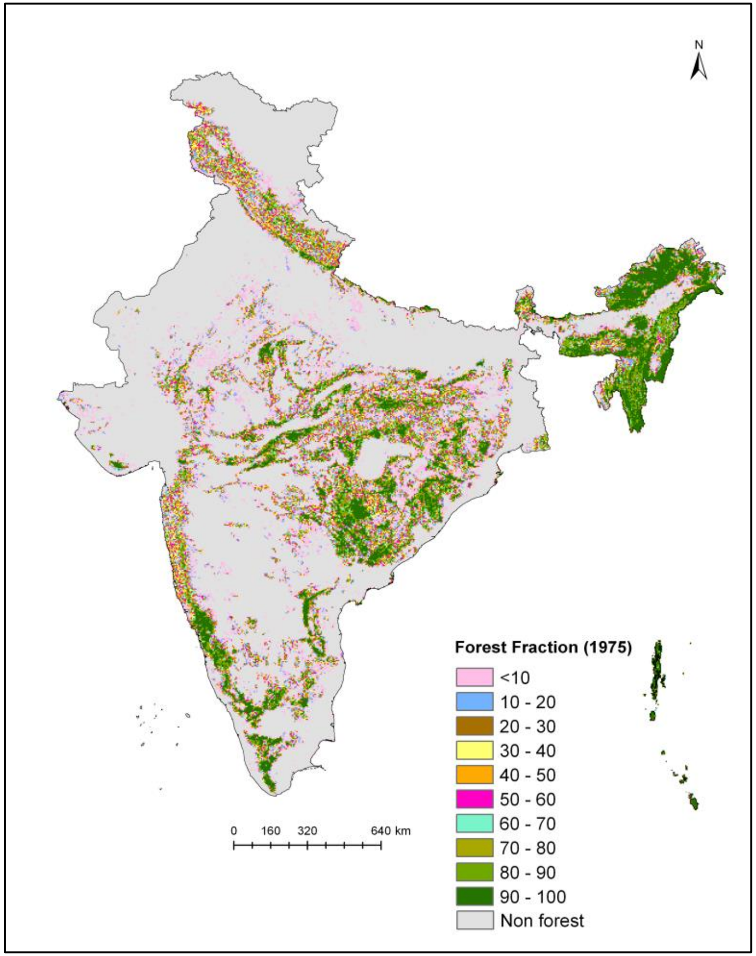


Forest Fraction, 2013

Fractional Forest Cover (5km Grid)



Forest Fraction, 1930

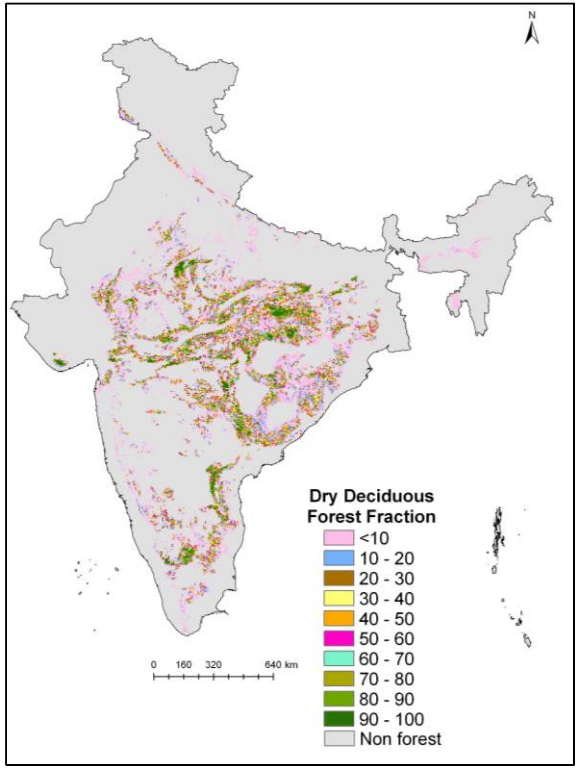


Forest Fraction, 1975

Forest Type (5km Grid)

Vegetation classification is prerequisite for understanding carbon stocks, biodiversity, sustainable use of natural resources and global change. The vegetation types reflect all the structural and functional attributes of vegetation in relation to the climate. India, a mega-diverse country, possesses a wide range of climate and vegetation types along with a varied topography. The present study has classified forest types of India based on multi-season Resourcesat-2 Advanced Wide Field Sensor (AWiFS) data in conjunction with spatial information on climate, elevation, phenology and large floristic database. The study has characterized 14 forest cover types and seven scrub types. Hybrid classification approach has been used for the classification of forest types. The classification of vegetation has been carried out based on the ecological rule bases followed by Champion and Seth (1968) scheme of forest types in India. Uniqueness of the present study lies in preparation of integrated classification scheme to suit with existing global and national vegetation legends, natural forest definition and utilization of 56m spatial resolution multi-season Resourcesat-2 AWiFS data satellite data of 2013.

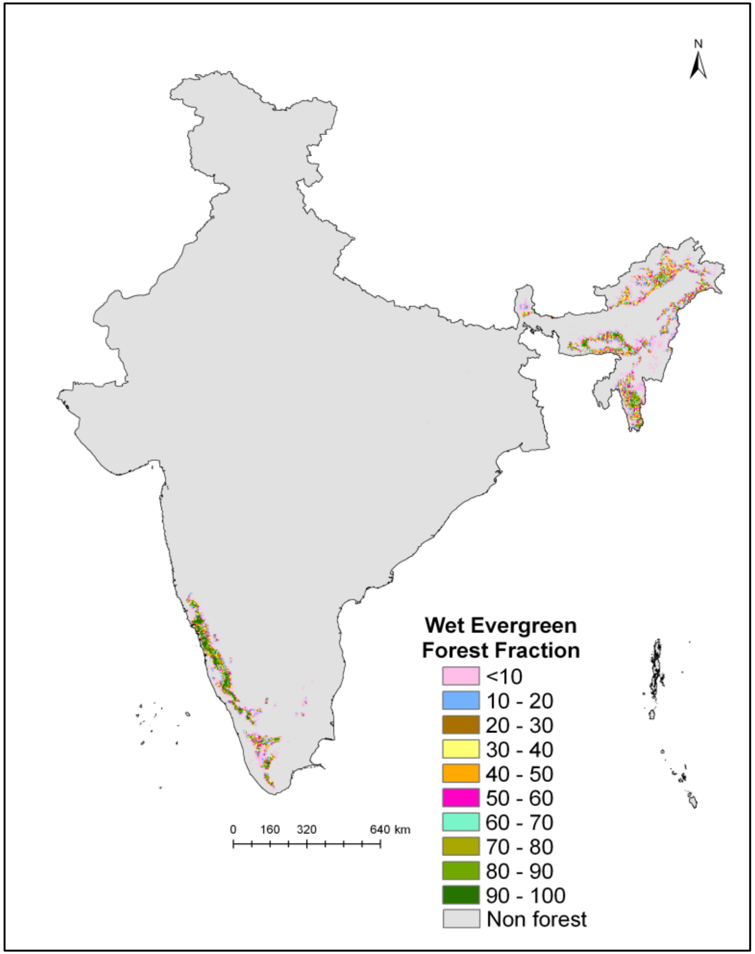
The natural vegetation cover was estimated to be 29.36% of total geographical area of India. The predominant forest types of India are tropical dry deciduous and tropical moist deciduous. Of the total forest cover, tropical dry deciduous forests occupy an area of 2,17,713 km^2 (34.80%) followed by 2,07,649 km^2 (33.19%) under tropical moist deciduous forests, 48,295 km^2 (7.72%) under tropical semi evergreen forests and 47,192 km^2 (7.54%) under tropical wet evergreen forests.



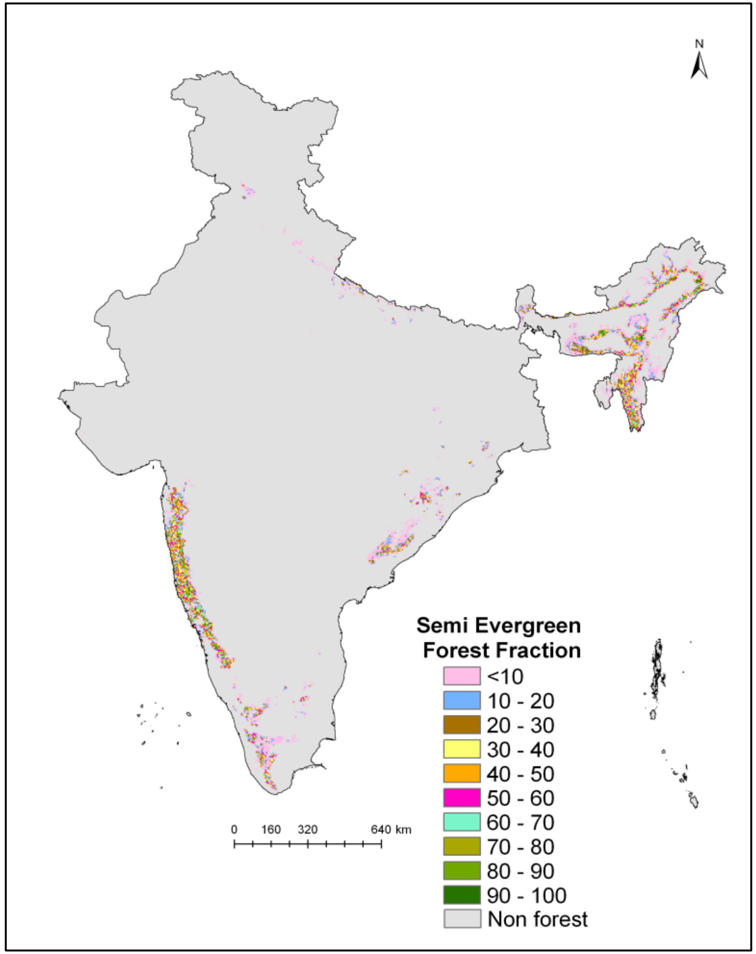
The study has brought out a comprehensive vegetation cover and forest type maps based on inputs critical in defining the various categories of vegetation and forest types.

This spatially explicit database will be highly useful for the studies related to changes in various forest types, carbon stocks, climate-vegetation modeling and biogeochemical cycles.

Forest Type (5km Grid)

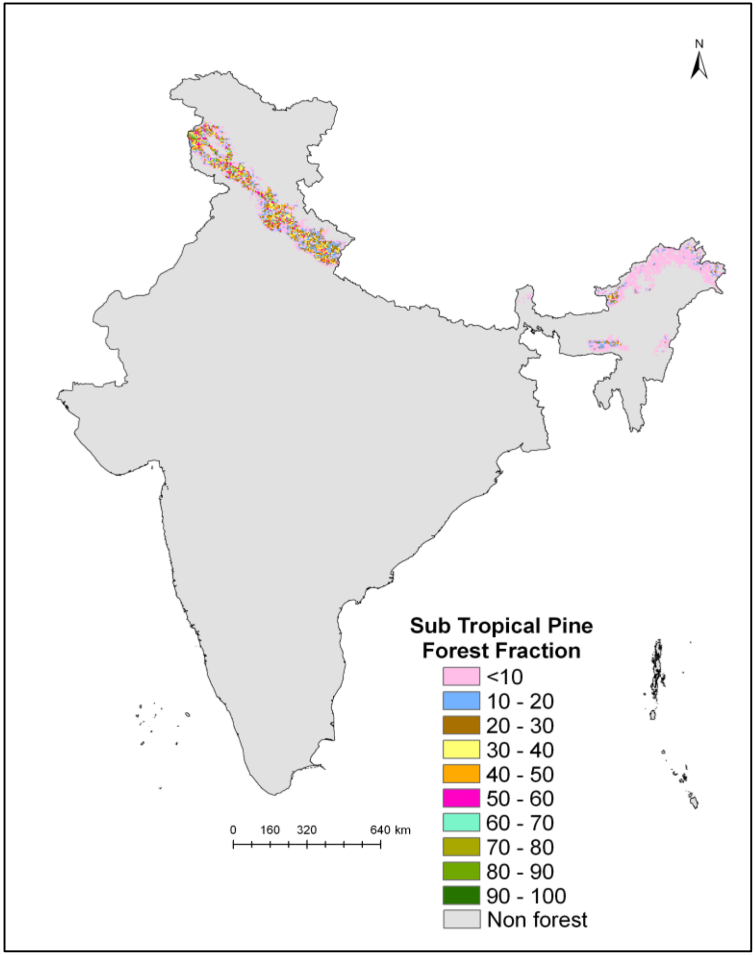


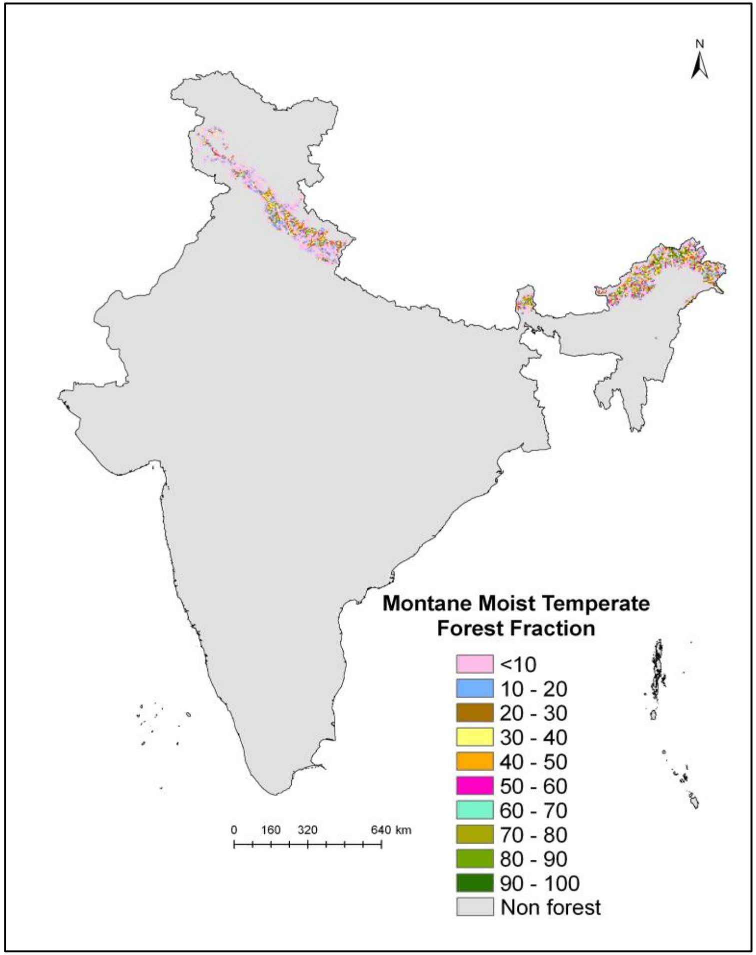
Wet Evergreen Forest Fraction



Semi Evergreen Forest Fraction

Forest Type (5km Grid)





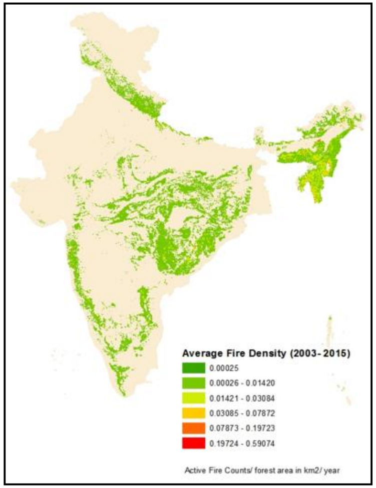
Sub Tropical Pine Forest Fraction

Montane Moist Temperate Forest Fraction

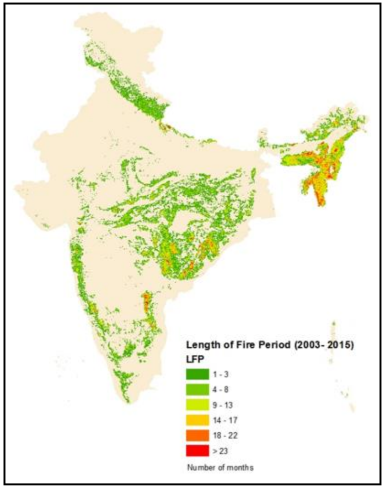
Forest Fire Regime

Fires play an important role in the natural changes that occur in Earth's ecosystems. Burning of tropical forests contributes 2.4 gigatons of carbon per year; or, about 30 percent of the total. Smoke and aerosol particles (representing one of the greatest areas of uncertainty regarding climate change) from large-scale biomass burning can rise high into the troposphere and be carried long distances by wind currents. (http://earthobservatory.nasa.gov/Features/GlobalFire/fire_4.php)

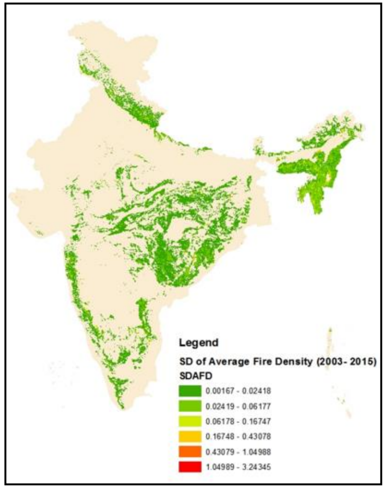
- Fire regime over India was analysed using the MODIS fire record from 2003 to 2015.
- The analysis used AQUA MODIS daytime fires for the 2003 - 2015 time period.
- Only detections with a detection confidence of over 10% and flagged as forest by using the NRSC forest fraction layer were used in the analysis.



Average fire density (2003-15)

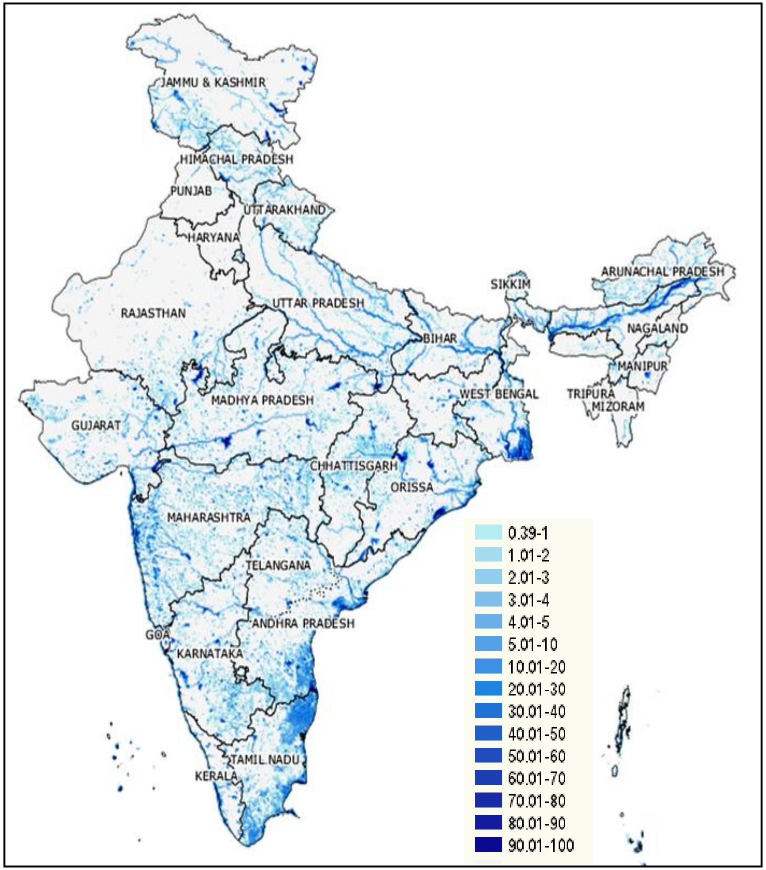


Length of fire period



SD of AFD

Satellite Derived Information on Water Bodies Area (WBA) and Water Bodies fraction (WBF)



Water Bodies Fraction (%) 3'X 3' Grid

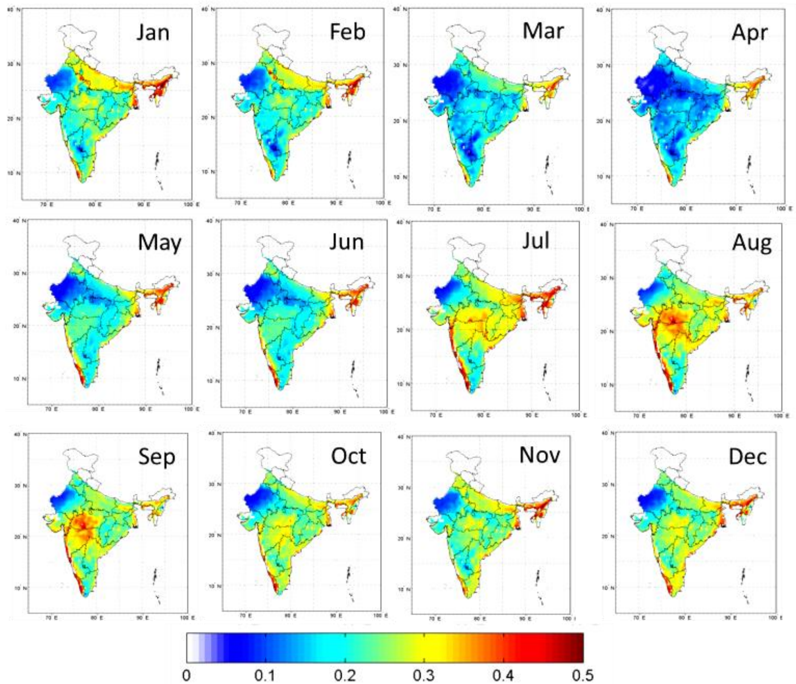
Water at the Earth's surface and in the atmosphere exerts a strong moderating effect on climate. Generally speaking, the higher the water content in the air, the more moderate (less extreme) the climate.

Water bodies consist of all surface water bodies viz. reservoirs, irrigation tanks, lakes, ponds, and rivers / streams and vary in spatial extent as a function of rainfall intensity and amount, etc., over a season / year. In addition to these surface water bodies, there are other areas representing water surface that may appear due to flood inundation, depression storages in flood plains, standing water in rice crop areas during transplantation stages, etc. These components are seasonal and may exist for small time period (days/weeks).

Water bodies of the first category delineated using the satellite data are presented here at the 3'X 3'grid. Resourcesat-2 AWiFS, RISAT-1 MRS available since 2012 were utilized for the study.

Surface Soil Moisture (Satellite)

Soil moisture is one of the ECVs that plays an important role in partitioning the rainfall in to infiltration and runoff components, solar radiation in to latent and sensible heat components etc. Using Level-3 brightness temperature data from Advanced Microwave Scanning Radiometer for EOS (AMSR-E) aboard Aqua, surface soil moisture is derived. The retrievals are made with a Land Parameter Retrieval Model (LPRM). The implementation depends only on AMSR-E brightness temperature data for surface temperature and vegetation cover apart from static parameters like soil texture. The vegetation optical depth is derived from the microwave polarization difference index (MPDI). Surface temperature is derived using 37 GHz V-polarized brightness temperature data. The surface soil moisture is available in standard format with 25 km resolution with India coverage once in two days.



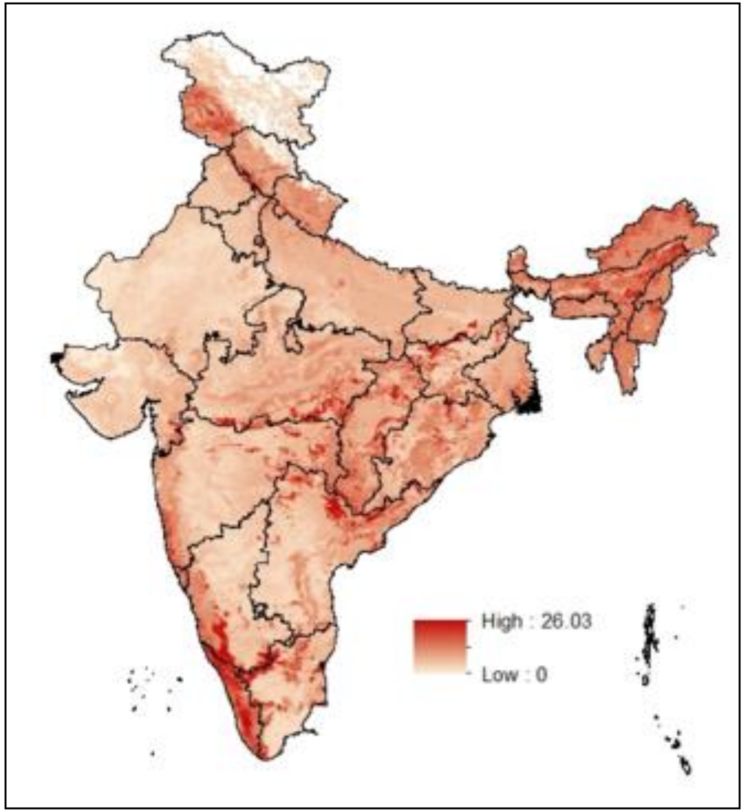
Monthly Averaged Soil Moisture (m3/m3) over India (2002-2011)

Ref- NRSC Document No:NRSC-ECSA-ACSG-AUG-2014-TR-645

Mean Soil Carbon Density

Inventories of soil carbon stocks are needed to assess the possible impacts of global climate change on soil organic , inorganic carbon content in relation to potential green house gas emissions. Soil holds a significant part of the global carbon stock and hence there is growing interest in assessing the role of soil as a source or sink for carbon emissions. A pre-requisite for such assessments is an estimate on the existing Carbon stock in soil and its dynamics under different land-use management practices and forest ecosystems.

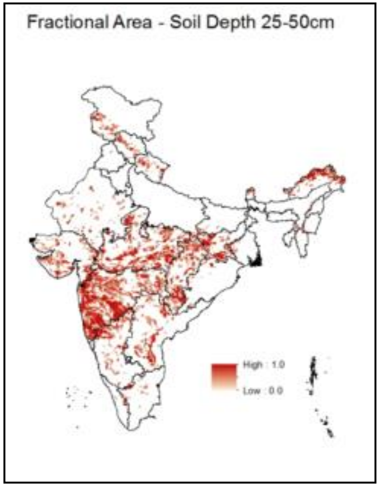
Spatial assessment of soil Carbon (organic and inorganic) was made using about 1198 soil profile observations spread across various agro-climatic zones using digital mapping techniques. Subsequently the mean carbon density was computed at 5km spatial resolution.

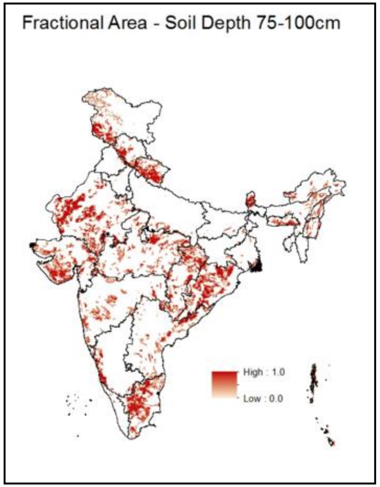


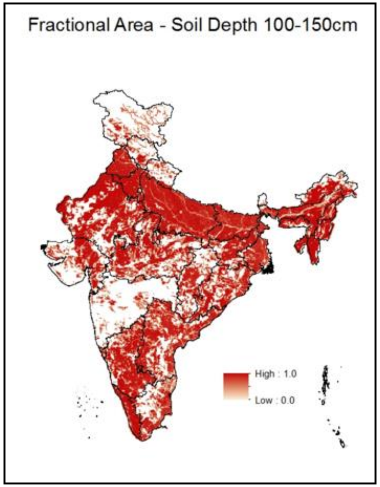
Mean-total Organic Carbon density

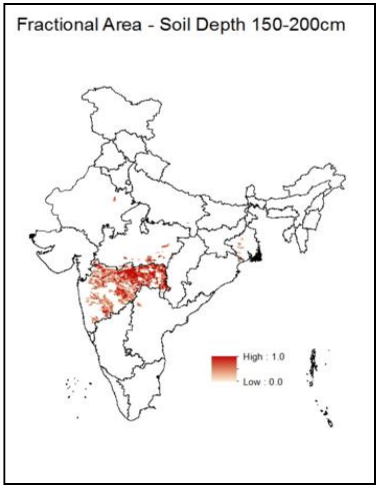
Soil Depth

Soil depth is an important soil property that governs the available space for growth of roots besides water holding capacity. Soil depth is defined as the depth (in cm) to a lithic or paralithic contact (USDA Soil Survey Manual). The soil depth as available from existing soil maps at various scales has been categorized in to Very shallow (< 25 cm), Shallow (25-50 cm), Moderately shallow (50-75 cm), moderately deep (75-100 cm), Deep (100-150 cm), Very deep (150- 200 cm) and converted to fractional area of respective depth class at 5km resolution. These outputs should be useful for various soil and plant growth modeling activities.



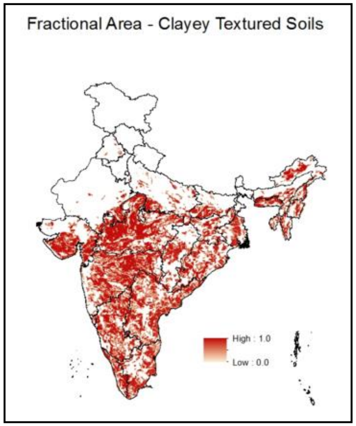


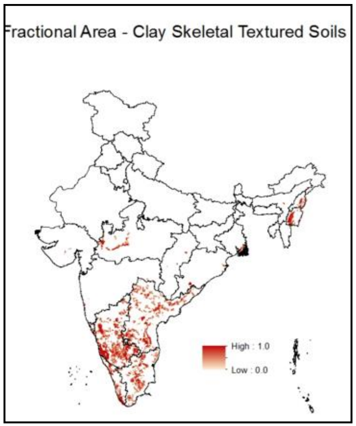


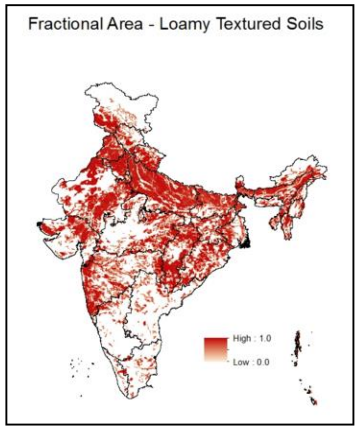


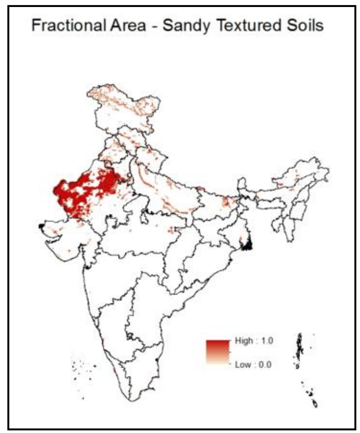
Soil Texture

Soil texture is the relative content of particles of various sizes, such as sand, silt and clay in the soil. Texture influences the ease with which soil can be worked, the amount of water and air it holds, and the rate at which water can enter and move through soil. The soil texture class as available from existing soil maps has been categorized in to sandy, loamy, clayey and clayey skeletal and converted to fractional area of respective texture class at 5km resolution. These outputs should be useful for various climatic, soil and plant growth modeling activities.



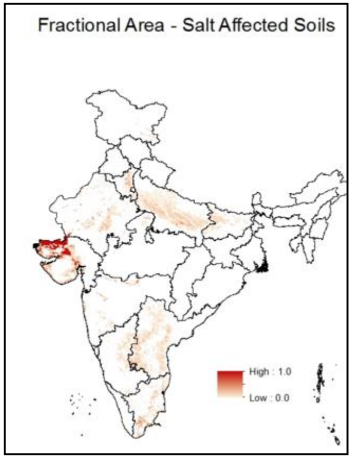


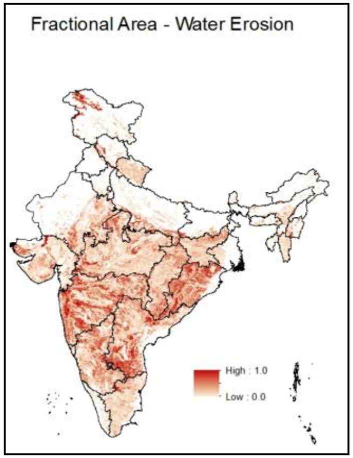


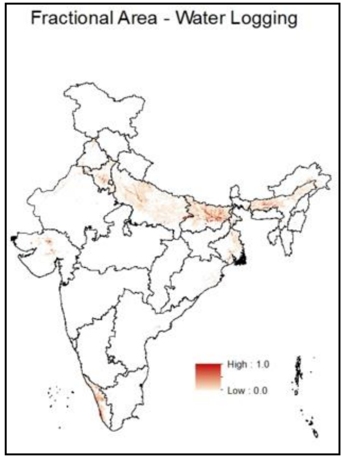


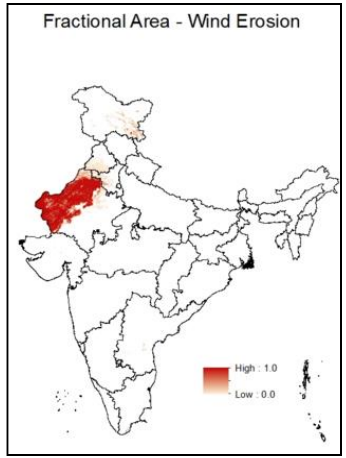
Land Degradation

The information on land degradation is needed for a variety of purposes like planning reclamation programs, rational land use planning, for bringing additional areas into cultivation and also to improve productivity levels in degraded lands. The land degradation map prepared on 1:50,000 scale using LISS-III data of 2005-6 has been overlaid with 5km grid and fraction of various land degradation processes with in the grid have been computed. This along with other NICES products should help in understanding the variation in land processes at regional scale.







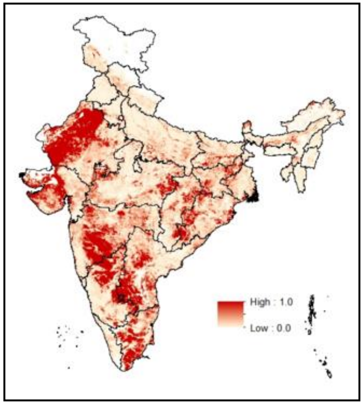


Annual Cropland Data

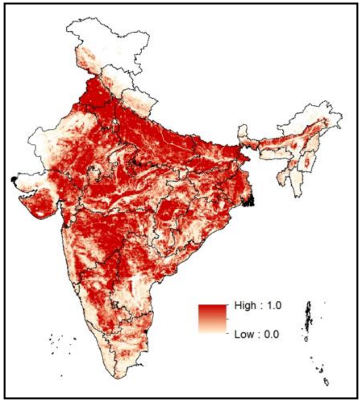
The fractional net sown area products under various cropping seasons of 10 annual cycles starting from 2004 - 05 is a valuable information for understanding the contribution of land cover changes in meso-scale climatological and hydrological models. This information serves as primary database for global environmental issues like biodiversity, climate change, land cover- atmosphere interactions, carbon sinks etc.

The annual cropland products were the integrated outcome of the Land use land cover (LULC) output generated at 56m resolution under National Level LULC mapping on 1:2,50,000 scale using multi-temporal AWiFS project. The study involved use of multi temporal AWiFS data covering Kharif (Aug-Nov), Rabi (Jan-Mar), Zaid (April-May) seasons to address spatial and temporal variability in cropping pattern. The temporal data over 10 years period provides a good understanding on seasonal dynamics across geographical regions of India.

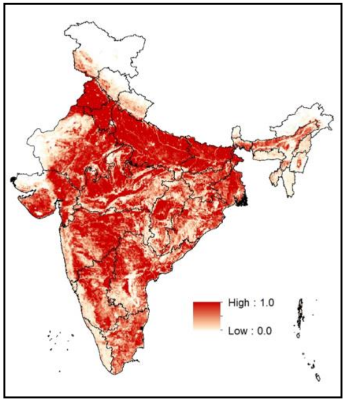
Fraction area
Fallow 2014-15



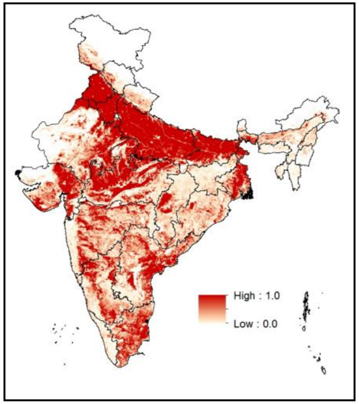
Fraction area
Kharif 2014-15



Fraction area
Net Sown 2014-15



Fraction area
Rabi 2014-15



Ocean Products

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S.No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
1	Daily Ocean Heat Content of 700m Layer	TMI/AMSR-2 SST & AVISO Altimeter SSHA	Indian Ocean	Jan 2002 –May, 2017	0.25°	Daily	~0.5-1MB
2	Daily Tropical Cyclone Heat Potential	TMI/AMSR-2 SST & AVISO Altimeter SSHA	Indian Ocean	Jan 1998 –May, 2017	0.25°	Daily	~0.5MB
3	Ocean Heat Content (OHC) and Ocean Mean Temperature (OMT) at different Depth	TMI/AMSR-2 SST & AVISO Altimeter SSHA	Indian Ocean	Jan 1998–May, 2017	0.25°	Daily	~0.5MB
4	Ocean Surface Winds						
4.1	Ocean Surface Winds	Oceansat - 2/ OSCAT/SCATSAT-1	Global Ocean	Jan 2010 –Feb 10, 2014 17-Oct-2016 to 4th May, 2018	0.5° &0.25°	Daily	~2MB
4.2	Ocean Surface Winds	Oceansat - 2/ OSCAT	North Indian Ocean	Jan 2010–Feb 10, 2014	25 km	Daily	~2MB
5	Wind Stress						
5.1	Wind Stress	Oceansat - 2/ OSCAT SCATSAT-1	Global Ocean	Jan 2010 –Feb 10, 2014 17-Oct-2016 to 4th May, 2018	0.5° &0.25°	Daily	~2MB
5.2	Wind Stress	Oceansat - 2/ OSCAT	North Indian Ocean	Jan 2010 –Feb 10, 2014	25 km	Daily	~2MB
6	Wind Curl						
6.1	Wind Curl	Oceansat - 2/ OSCAT SCATSAT-1	Global Ocean	Jan 2010 –Feb 10, 2014 17-Oct-2016 to 4th May, 2018	0.5° &0.25°	Daily	~2MB
6.2	Wind Curl	Oceansat -2/ OSCAT	North Indian Ocean	Jan 2010 –Feb 10, 2014	25 km	Daily	~2MB

Ocean Products

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S.No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
7	Ekman Currents	SARL ALTIKA/ OSCAT/SCATSAT	Global Ocean	Mar 2013 - Jan 2018	0.25 °	Daily	~2MB
8	Geostrophic Currents	SARL ALTIKA/ OSCAT/SCATSAT	Global Ocean	Mar 2013 - Jan 2018	0.25°	Daily	~2MB
9	Sea Surface Height Anomaly	SARAL ALTIK	Global Ocean	Mar 2013 - Jan 2018	0.25 °	Daily	~1MB
10	Ocean Surface Currents	SARAL ALTIKA/ OSCAT	Indian Ocean	Mar 2013 - Feb 2014	0.25 °	Daily	~1MB
11	Eddy Kinetic energy EKE	Altimeter/CMEMS	Indian Ocean	Jan 1993 - Apr 2018	0.25°	Daily	~400KB
12	Monthly Mean Sea Level Anomaly (MMSLA)	AVISO/ Altimeter	Indian Ocean	Jan 1993 - Dec 2011	1°	Monthly	~200KB
13	Ocean Color Datasets for North Indian Ocean and Global - 1 KM - 2 Days - 8 Days - Monthly						
13.1	Chlorophyll Concentration (CHL_ OC2)	Oceansat - 2/ OCM II	North Indian Ocean	Jan 2010 - Jan 2017	1 km	2 Days 8 Days Monthly	~30MB
13.2	Chlorophyll Concentration (CHL_ OC4)	Oceansat -2/ OCM II	North Indian Ocean	Jan 2010 - Jan 2017	1 km	2 Days 8 Days Monthly	~15MB
13.3	Diffuse Attenuation Coefficient at 490 nm (KD_490)	Oceansat - 2/ OCM II	North Indian Ocean	Jan 2010 - Jan 2017	1 km	2 Days 8 Days Monthly	~30MB
13.4	Chlorophyll Concentration (CHL_ OC2)	Oceansat - 2/ OCM II	Global Ocean	Jan 2011 – Dec 2016	4 km	8Days Monthly	~30MB
13.5	Chlorophyll Concentration (CHL_ OC4)	Oceansat - 2/ OCM II	Global Ocean	Jan 2011 – Dec 2016	4 km	8Days Monthly	~15MB
13.6	Diffuse Attenuation Coefficient at 490 nm (KD_490)	Oceansat - 2/ OCM II	Global Ocean	Jan 2011 – Dec 2016	4 km	8Days Monthly	~30MB

Ocean Products

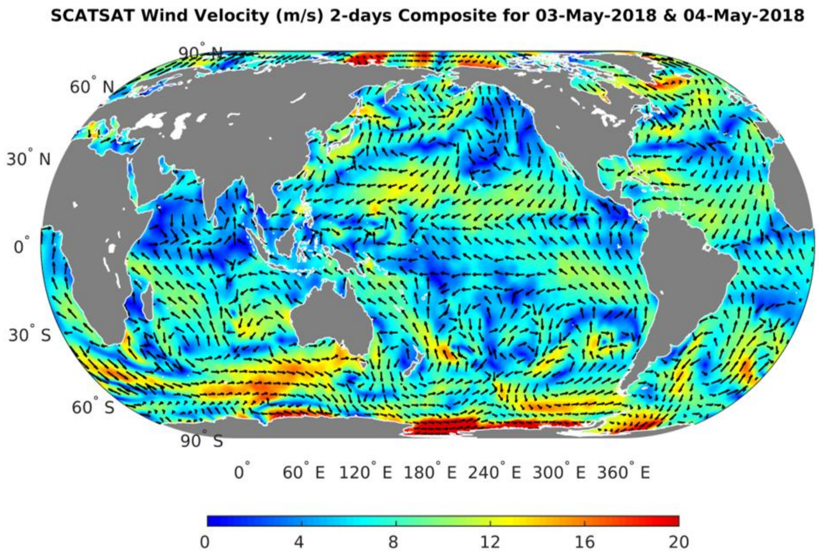
S.No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
14	Sea Level Pressure (SLP_Globe)	OSCAT/SCATSAT-1	Global Ocean	Jan 2010 – Feb 10, 2013; 11-Oct-2016 to 21-May-2018	50 Km	Daily	~1.4 MB
15	Co-Tidal Map (K1O1) Amplitude-Phase	SARL ALTIKA/ Altimeter	5.5º N-24º N 68º E to 89.5º E	Stationary map (Based on 2013-2015 simulations by Hydro-dynamic model)	2'	–	~1MB
16	Co-Tidal Map (M2S2) Amplitude-Phase	SARL ALTIKA/ Altimeter	5.5º N-24º N 68º E to 89.5º E	Stationary map (Based on 2013-2015 simulations by Hydro-dynamic model)	2'	–	~1MB
17	26º Degree Isotherm	Model Derived	30S-30N;30E-120E	July 2013 - Dec 2017	0.5 °	Daily	~0.5MB
18	Tropical Cyclone Heat Potential	Model Derived	30S-30N;30E-120E	July 2013 - Dec 2017	0.5 °	Daily	~0.5MB
19	Total Alkainility (TA)	Aquarius & Modis	Global	Jan 2014- Aug 2017	25 km	Weekly	
20	Dissolved Inorganic Carbon (DIC)	Aquarius & Modis	Global	Jan 2014- Aug 2017	25 km	Weekly	

Ocean Surface Winds

Surface winds over global oceans drive heat, mass and momentum transfer between the ocean and atmosphere, thereby forcing the surface circulation of the oceans. Sea surface wind is one of the main input for the operational oceanography as well as climate studies in terms of improving the weather forecast using numerical weather prediction models .

Global gridded daily and two-day composite wind fields of Scatterometer-1 (SCATSAT-1) are generated using variational analysis. For this, ascending and descending pass data of SCATSAT version 1.1.3 have been used.

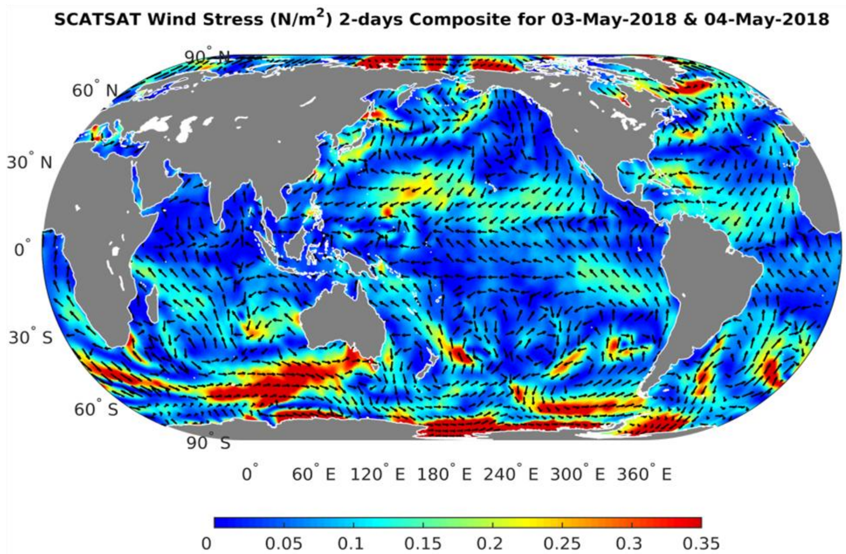
Gridded wind fields are retrieved for the entire operational period of SCATSAT-1 spanning from October 2016 to till date.

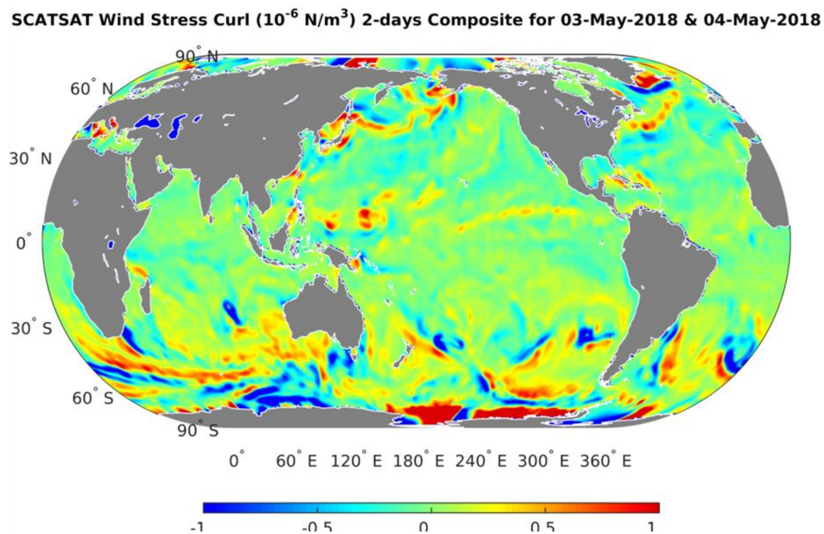


Wind Stress and Wind Stress Curl

It is planned to create a database of wind velocity, wind stress and wind stress curl from scatterometer wind fields to support the climatic studies. Wind velocity, Wind stress and Wind Stress Curl, global products have been computed from 2-Day wind composites, generated using SCATSAT L3 wind data.

In the process of wind stress computation, Large and Pond (1981) drag coefficients are used. While wind stress curl has been estimated using cross directional differential of wind stress. In the process, MATLAB tools are used to map wind products in standard formats with 50 km and 25 km resolution.



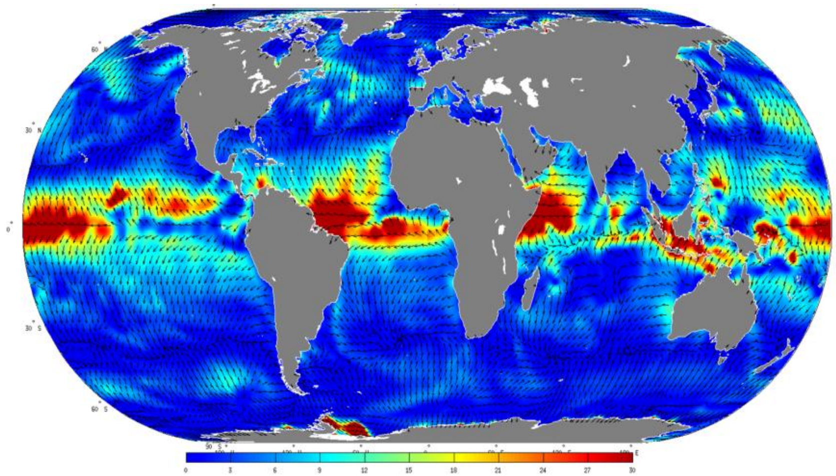


Ekman and Geostrophic Currents

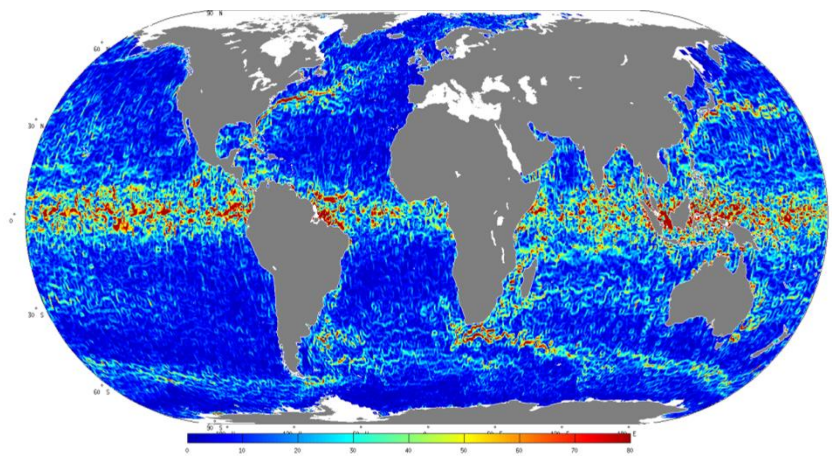
Total surface currents are primarily composed of wind driven Ekman currents and pressure gradient driven geostrophic currents. The scope of the current observations can be seen in the navigation and optimization of shipping routes, dispersion and drift of pollutants. Particularly, algal blooms and oil spills, besides their use in tracing mass and heat distribution across the ocean boundaries.

The Ekman Surface currents estimated from wind stress components. The ocean surface currents are estimated from satellite observations of surface wind from SCATSAT and Sea Surface height from SARAL AltiKa.

The data sets available since March 2013. The products are validated with drifting buoy observations indicating a good relationship between the observations.



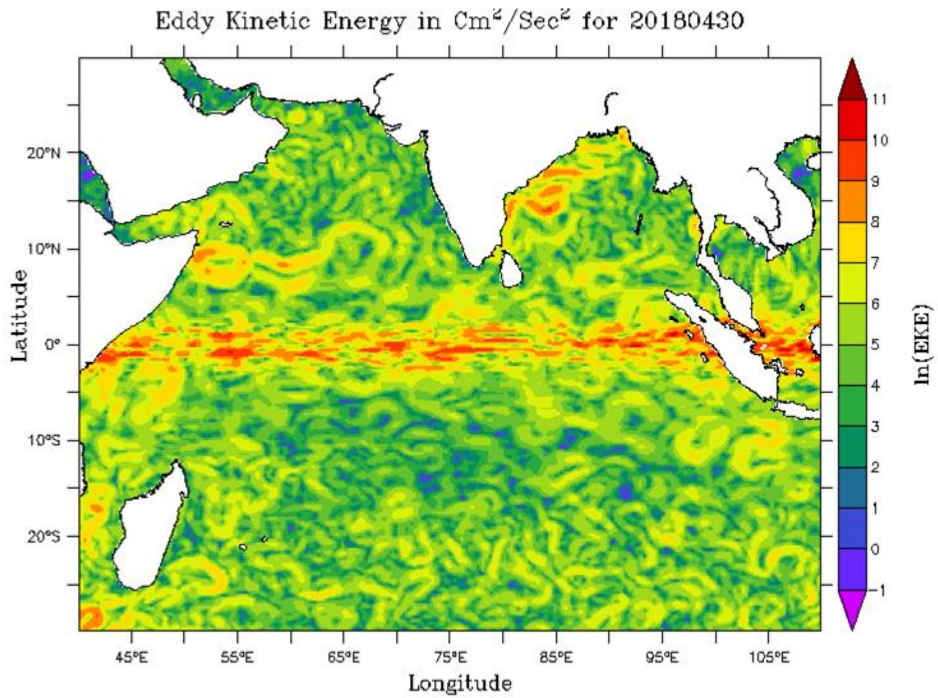
SCATSAT Ekman currents (cm/s) 05-Feb-2017



SARAL-Altika Geostrophic currents (cm/s) 25km 02-Feb-2017

Eddy Kinetic Energy (EKE)

The kinetic energy of ubiquitous eddies in the ocean play a significant role in transporting water mass, heat and nutrients in the ocean. The Eddy Kinetic Energy over Tropical Indian Ocean is calculated based on Satellite measured Sea Level Anomaly data. The product is generated on daily basis and monthly means with spatial resolution 0.25 x0.25 degree and it is available from 01-Jan-1993 to till date. SLA data are acquired from Copernicus Marine Environment Monitoring Service. Geostrophic velocity components (Zonal velocity, Meridional Velocity) have computed from SLA observations and have been used in the estimation of daily EKE.



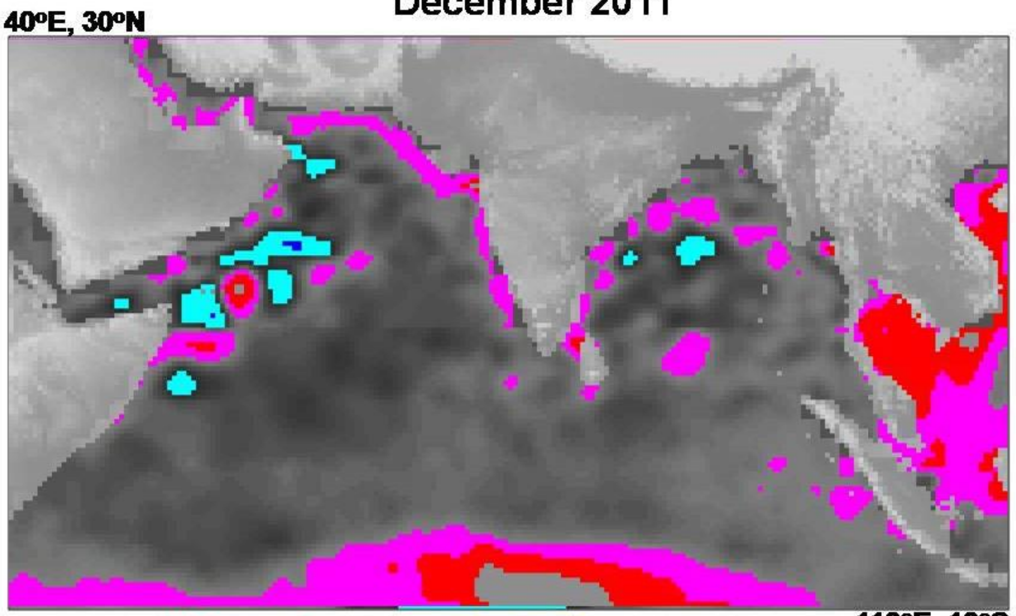
Monthly Mean Sea Level Anomaly

Mean sea level anomaly (MSLA) maps (associated with Eddy kinetic energy) convey the area of ocean water sinking and upwelling, which help in many ways to understand the processes of primary productivity, air-sea gas flux and mass drift in the surface layers.

The data are available from Topex /Poseidon, ERS-1/2 and Envisat and Jason-1 and 2, and Hy-2. Recently, SARAL AltiKa with Ka band sensor launched from India on 25 February 2013 in collaboration with the CNES, France.

Monthly distribution fields of MSLA is estimated from 1993 to 2011.

December 2011



Areas of Warm Core and Cold Core Eddies

Depth of 26^{0}C Isotherm and Tropical Cyclone Heat Potential

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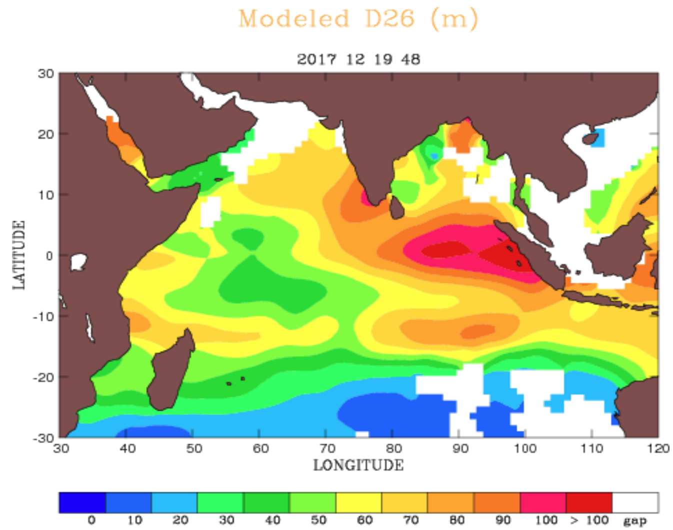
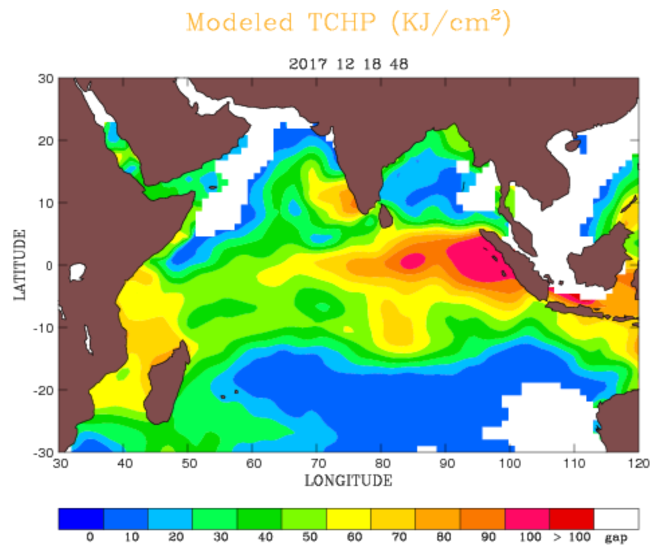
Two important ocean parameters, the depth of 26 °C isotherm (D26) and the Tropical Cyclone Heat Potential (TCHP) are responsible for genesis, intensification and propagation of tropical cyclones. Hence, monitoring of these two parameters and the ability for their advance prediction is quite essential.

One-dimensional (1-D) ocean mixed layer model is used to predict D26 and TCHP, 48 hours in advance at an interval of every six hours. The model is forced with forecast surface meteorological parameters obtained from an Atmospheric General Circulation Model. The model results are validated by comparison with D26 and TCHP computed from Argo temperature and salinity profiles for about four months representing the four major seasons in a year in the Indian subcontinent. Further, the entire process has been integrated as a single package and automated for operational use.





Sea Surface Height (SSH) of SARAL Altika

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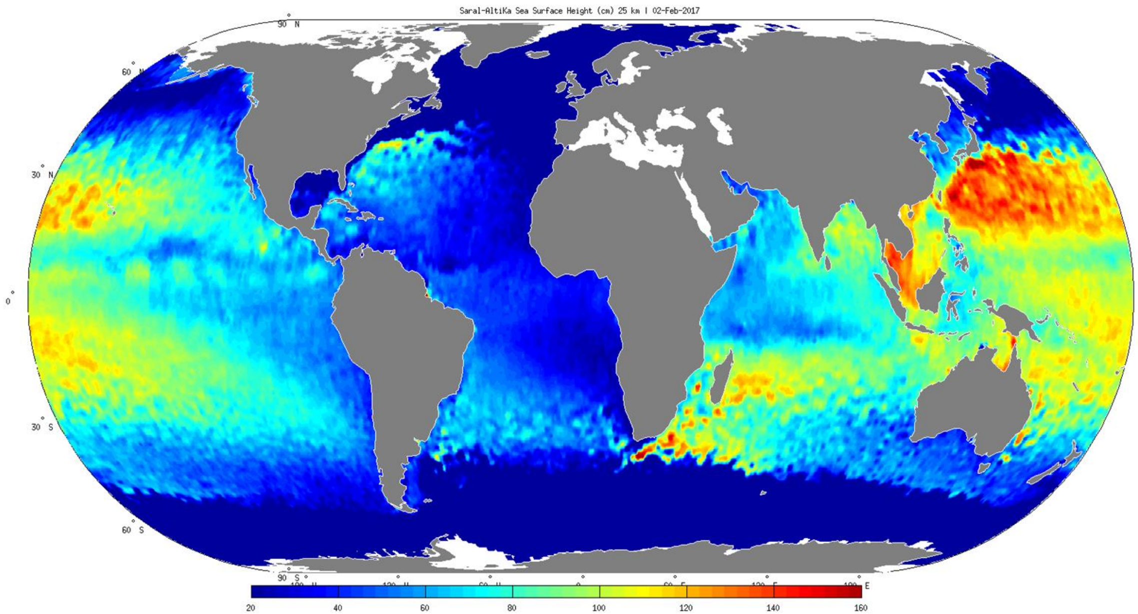
Sea Surface Height (SSH) data can be used for meteorological applications (i.e. weather), marine operations (i.e. fishing, boating, offshore operations), and other applications where knowledge of current ocean conditions are relevant.

Sea Surface Height (SSH) maps have been generated by gridding Saral-AltiKa along track data. For gridding, median interpolation of last 15 days along track data has been used.

The data sets are available for the period 2013-2017.

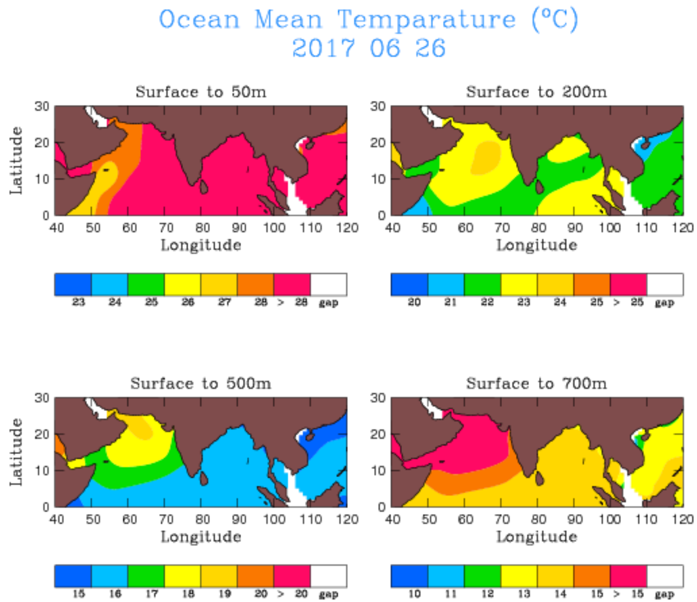


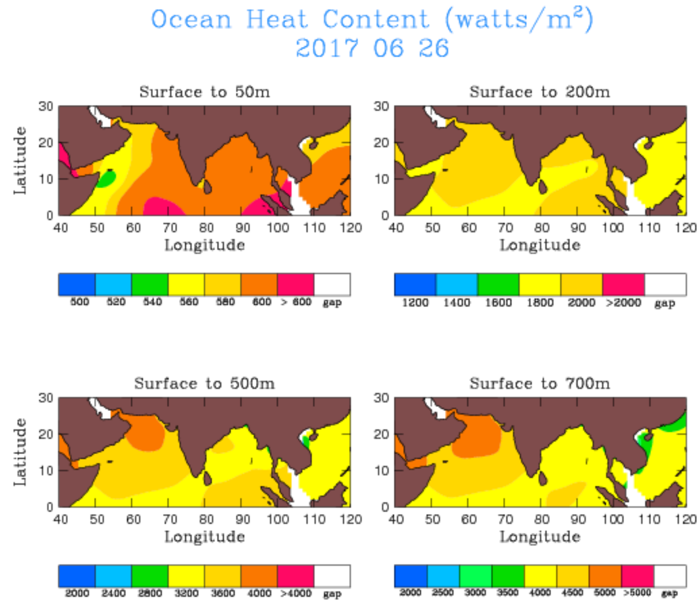
SARAL ALTIKA Sea Surface Height (cm) 25 km 02-Feb-2017

Daily Ocean Mean Temperature and Heat Content

Ocean heat content (OHC) and Ocean Mean Temperature (OMT) are important climatic parameters required for atmospheric and oceanic studies like cyclone & monsoon predictions and ocean heat transport estimations.

The data used to estimate these parameters are (a) sea surface height anomaly from the available altimeters, (b) sea surface temperature from AMSR2 (**A**dvanced **M**icrowave **S**canning **R**adiometer **2**) and the climatological values of OHC and OMT of various depths (50, 100, 150, 200, 300, 500, 700m and TCHP as an integral of OHC from surface to 26^{o}C isotherm and it's mean temperature). These parameters are estimated on a daily basis from 1998 to present using artificial neural network techniques.





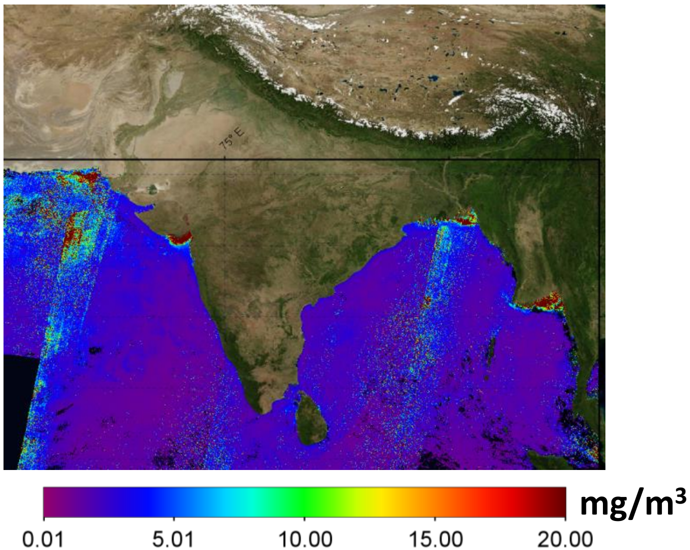
Ocean Chlorophyll from OCM

The oceanography division focus on calibration and validation of ocean colour products for oceanic waters by using in situ and satellite data. Presently, scientific issues such as primary production, upper ocean heating, dispersion of oceanic discharges and biogeochemical cycling in the ocean are being considered as important and has immediate societal relevance. In ocean, chlorophyll is one of major and important climate variable in terms of carbon fixation, primary productivity and global biogeochemical cycle studies. Hence, it is necessary to study this variable on regional to global scale over a long period time scale will provide the better solutions for the climate change studies. OCM-2 being a global sensor provides high resolution chlorophyll products for global ocean colour applications. Hence, there is a need to generate the ocean colour products compatible with the other contemporary global ocean colour sensor data in terms of processing platforms, atmospheric correction strategies, thresholds, flags and other stringent components like sun glint correction. In this context we adopted the global processing package namely, the SeaDAS: Seawifs Data Analysis System (SeaDAS), which is a comprehensive image analysis package for the processing, display, analysis and quality control of ocean color data developed and supported by NASA (http://seadas.gsfc.nasa.gov). SeaDAS is intended to support the previous and current and upcoming ocean colour sensors like SeaWiFS, MODIS, OCTS, CZCS, MERIS and OCM-2 as well. SeaDAS is all other ocean color sensors. The methods used to average and quality control the basic pixel information, as well as the temporal and spatial binning schemes used to provide fields of geophysical quantities, also come into play when attempting to merge ocean-colour data from other sensors. The goal of this study is to produce the best possible, large-scale representation of the current status of Ocean Colour data processing for generating the Level-3 ocean colour data products (binned) products accepted by the global community as well as the applications and validation of OCM-2 chlorophyll with the *in-situ* observations

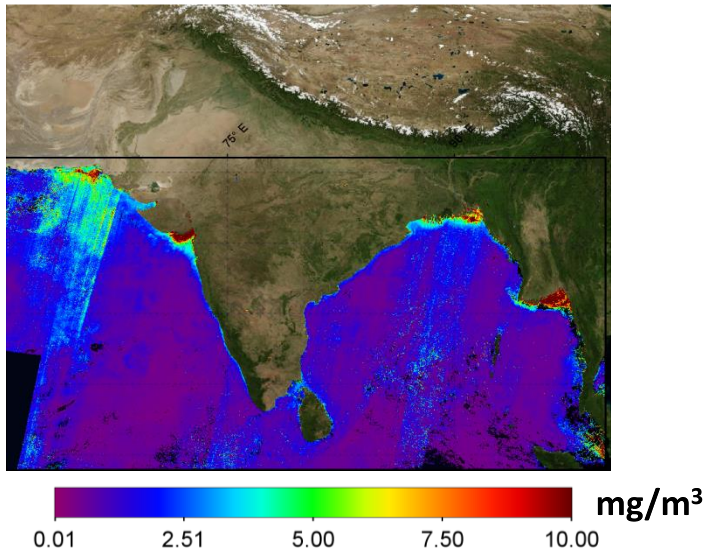
Chlorophyll Concentration (Chl-OC2 & OC4)

Chlorophyll-a concentration is one of the most important and one of the essential climate variables (ECVs) and the primary geophysical data product derived from ocean colour remote sensing.

The derived chlorophyll concentration (in space and time) can be used to resolve inter-annual to decadal changes in oceanic phytoplankton biomass in response to global environmental changes. OCM-2 Chlorophyll (OC2 & OC4) algorithms and products have been generated using SeaDAS (SeaWiFS Data Analysis System) for Local (North Indian Ocean/LAC). For NIO , 2-day, 8-day, monthly at 1KM products are generated from 2010-2016.



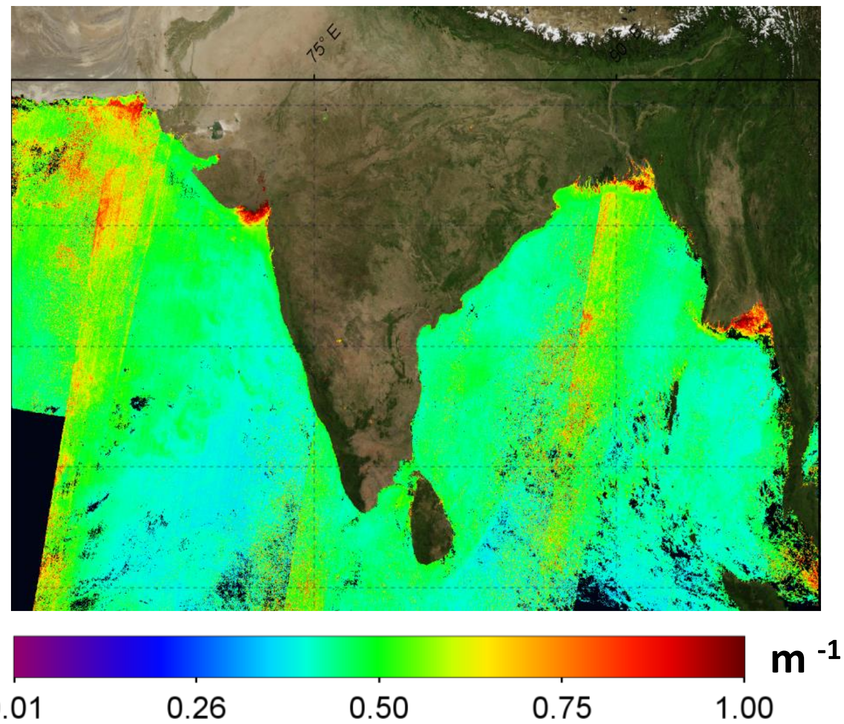
OCM-2 Chlorophyll from 2015 JAN 1-8 using OC2



OCM-2 Chlorophyll from 2015 JAN 1-8 using OC4

Diffuse Attenuation Coefficient at 490nm

Diffuse attenuation coefficient at 490 nm products has been generated using SeaDAS (SeaWiFS Data Analysis System) for Local (North Indian Ocean/LAC). For NIO , 2-day,8-day, monthly at 1KM and above products are generated from 2010-2016

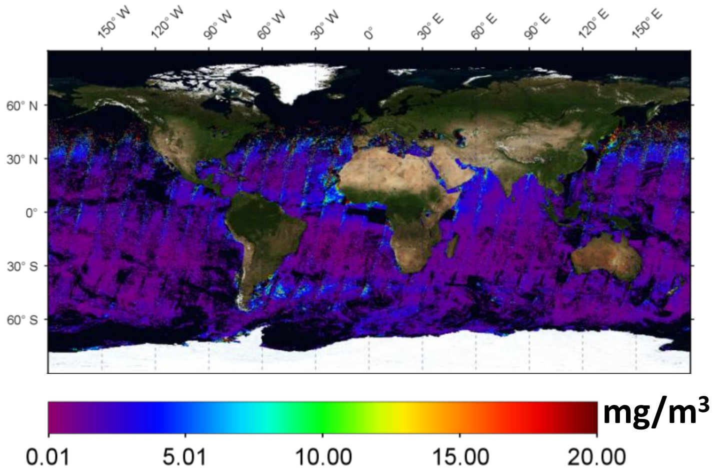


Diffuse attenuation coefficient 2015 JAN 1-8

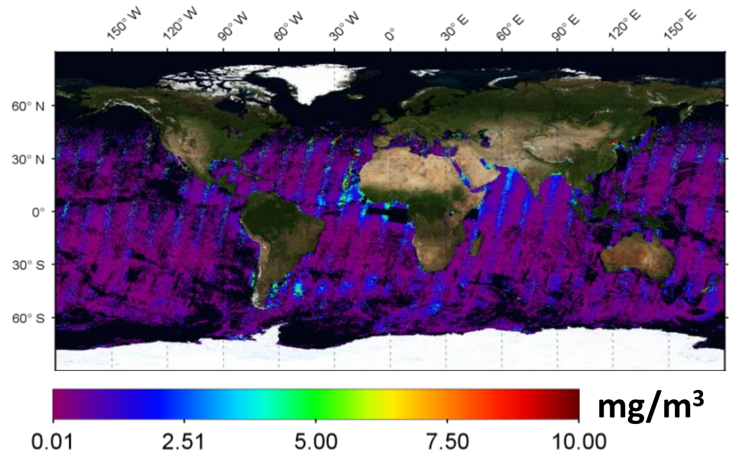
Chlorophyll Concentration (Chl-OC2 & OC4): Global

OCM-2 Chlorophyll (OC2 & OC4) algorithms and products has been generated using SeaDAS (SeaWiFS Data Analysis System) for Global Oceans(GAC).

For Globe 8-day and Monthly at 4KM and 9KM above products are generated from 2011 - 2016



OCM-2 Chlorophyll from 2015 JAN 1-8 using OC2



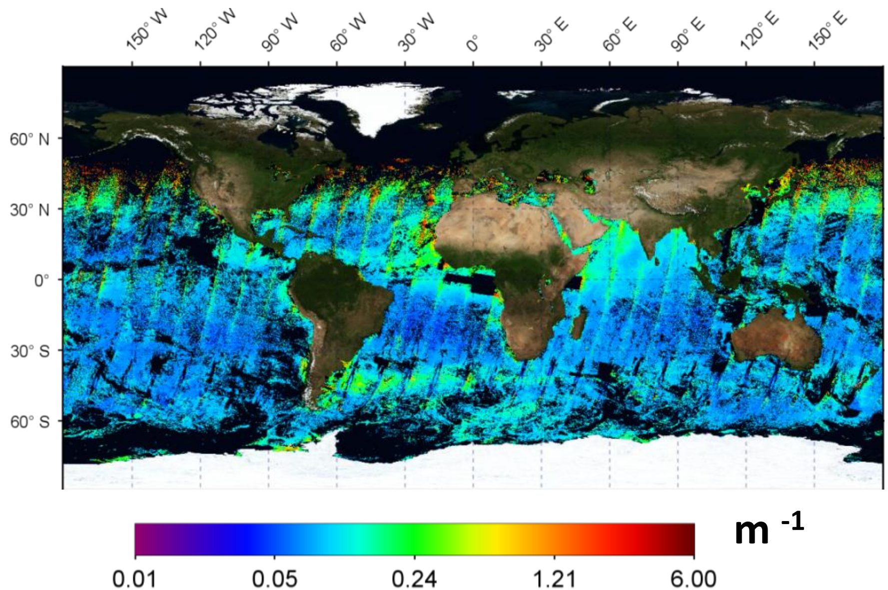
OCM-2 Chlorophyll from 2015 JAN 1-8 using OC2

Diffuse Attenuation Coefficient at 490nm : Global

In order to utilize remotely sensed data for monitoring and understanding coastal ecosystems, it is important to determine the relationship between water depth and the reflectance characteristics of various benthic components.

To characterize the water column, the parameter that controls the propagation of light through water, i.e., the diffuse attenuation coefficient, needs to be determined precisely. This coefficient of down welling irradiance, Kd(z, λ) is of particular interest because it quantifies the presence of light and the depth of the euphotic zone.

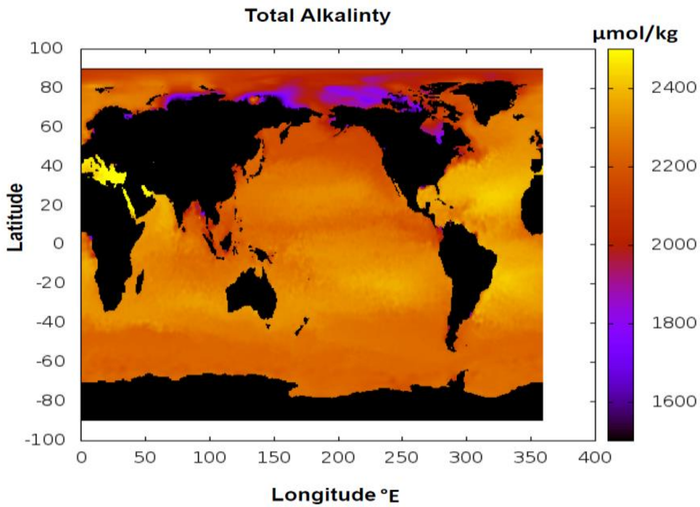
Diffuse attenuation coefficient at 490 nm products has been generated using SeaDAS (SeaWiFS Data Analysis System) for for Global Oceans(GAC). Global 8-day and Monthly 'diffuse attenuation coefficient' at 4KM and 9KM products are generated from 2011-2016

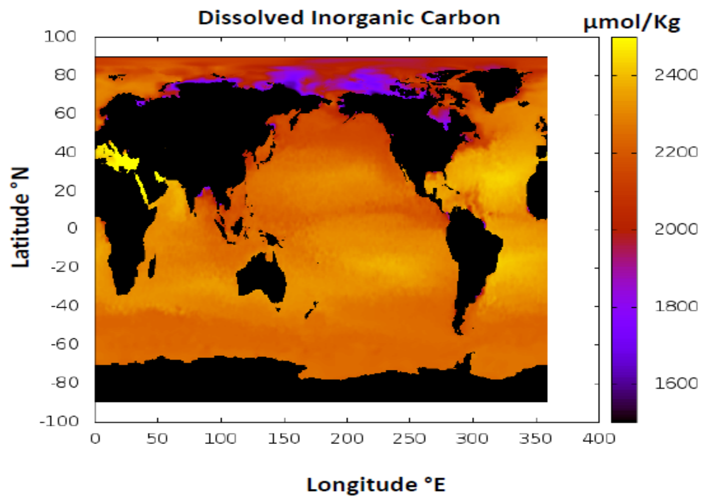


Diffuse attenuation coefficient 2015 JAN 1-8

Global surface ocean total alkalinity (TA) and dissolved inorganic carbon (DIC)

Total Alkanility (TA) represent the buffering capacity of the oceans and act as a natural feedback mechanism to the changing ocean pH because of rising atmospheric CO_2 which is slightly acidic in nature. With occurrence of regular coral bleaching large scale spatial satellite monitoring can help in understanding the trends associated with TA or pH in vice versa. On the other hand DIC represent dissolved inorganic carbon in ocean and act as an important sink of atmospheric of atmospheric CO2 in the form of carbonates and bicarbonates in ocean. It is also precursor of gross primary production in ocean where phytoplankton takes up the bicarbonates to making soft tissues causing under saturation in the ocean mixed layer. These data are now available starting from December 2013-August ,2017 with a spatial resolution of 25 km and weekly temporal scale.

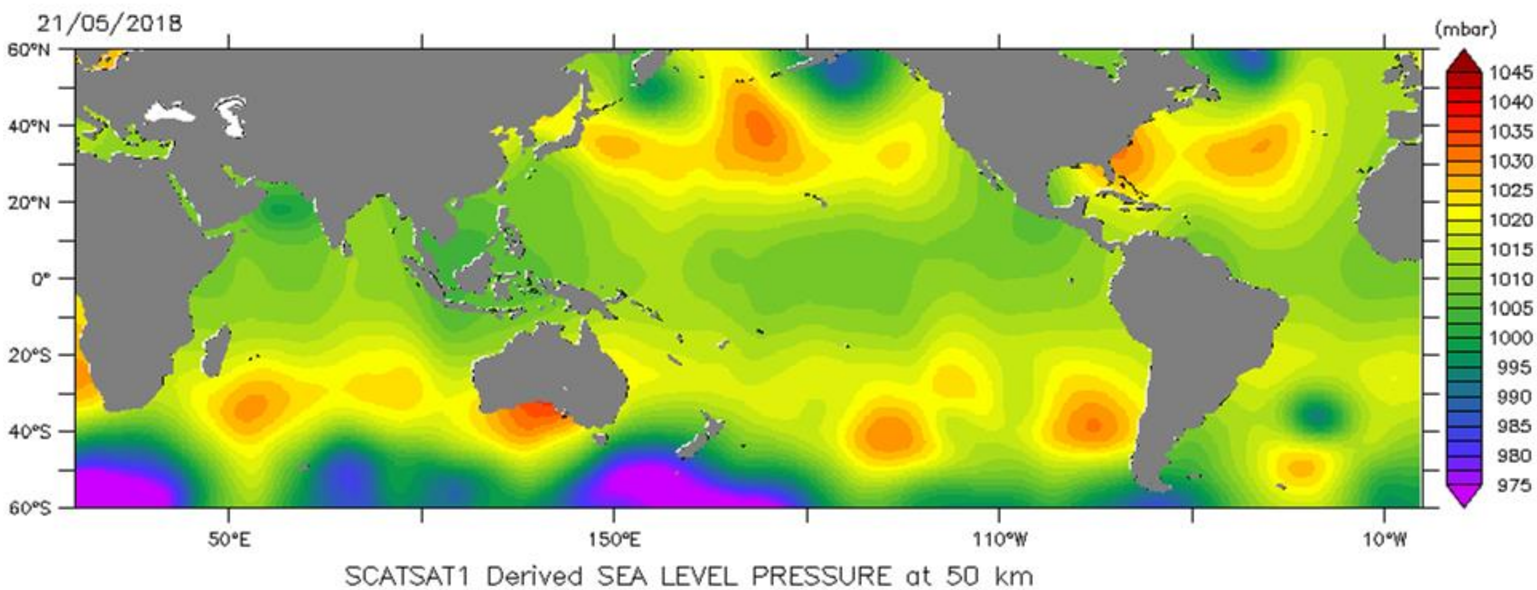




Global satellite derived surface profiles of total alkalinity (TA) and dissolved Inorganic carbon (DIC) for the month of March-2017 with ¼ degree grid.

Sea Level Pressure (SLP)

SLP plays vital role in global weather studies and influence the climate and Ocean circulation and one of the basic input parameter in ocean and atmospheric studies as well as Numerical Weather Prediction Models. The daily global SLP fields are generated from SCATSAT-1 winds, which will complement our earlier OSCAT SLP data product, using University of Washington Planetary Boundary Layer (UWPBL) model. The Data Interpolating Variational Analysis (DIVA) technique is used to make global composite from along track pressure fields. The SLP field are retrieved over the global ocean with 50km resolution. The estimated pressure fields are evaluated with the in-situ buoy measurements during the month of January 2017. A strong positive correlation (R= 0.7859) is found between UWPBL SLP and buoy SLP. The SCATSAT-1 SLP is retrieved since October 2016 to till date.

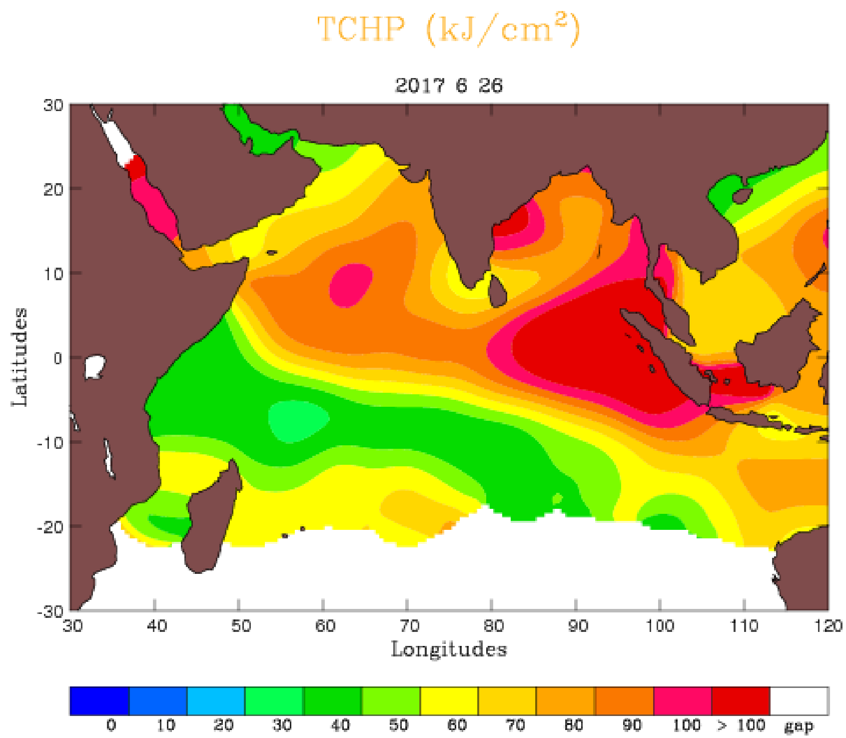


Daily Tropical Cyclone Heat Potential (TCHP)

Tropical cyclone heat potential (TCHP), an important ocean parameter influencing cyclones, is defined as the energy available for cyclones and is calculated by summing the heat content in a column where sea surface temperature is above 26ºC.

In view of the limitations of temperature profiles, methods have been evolved to estimate this parameter from satellite altimeter derived sea surface height anomalies (SSHA). The computation of TCHP on daily basis is carried out from the available altimeter observations of SSHA, sea surface temperature (SST) using AMSR2 and climatological depth of 26ºC isotherm.

The daily values of TCHP are available for a researcher to download from the NICES website from 1998 onwards over the north Indian Ocean spanning 30ºS-30ºN and 30ºE-120ºE.



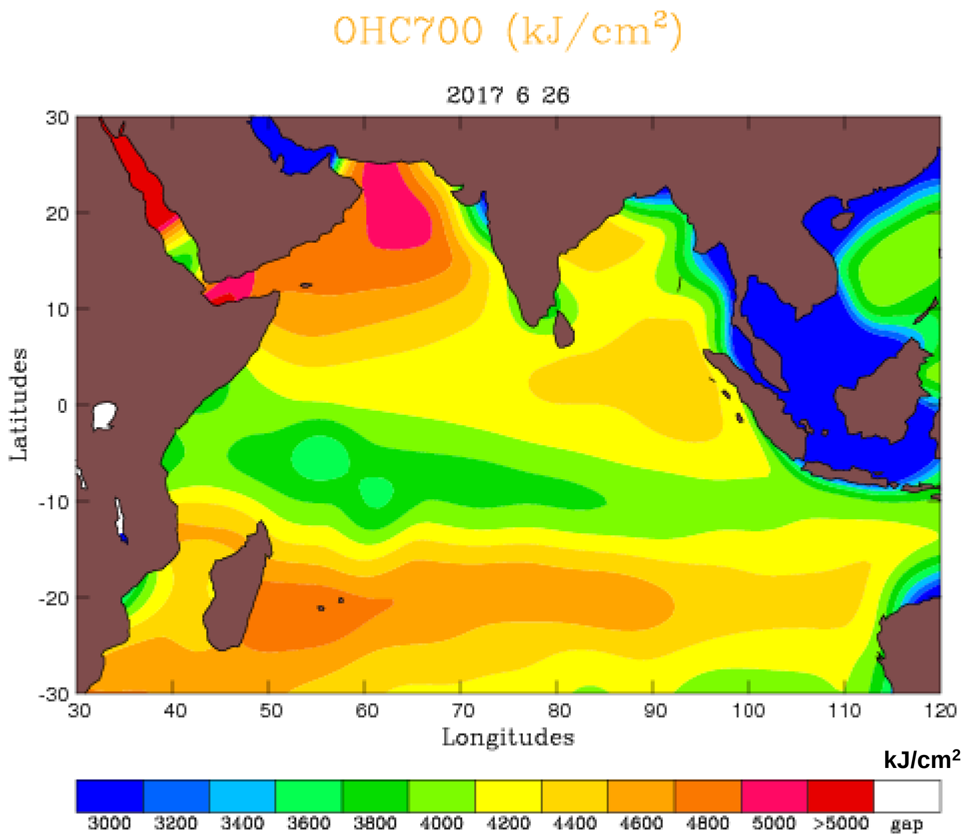
Daily Ocean Heat Content of 700m Layer

nrsc

Ocean Heat Content up to 700m depth (OHC700) is an important climatic parameter required for atmospheric and oceanic studies like cyclone and monsoon prediction and ocean heat transport estimations.

The data used to estimate this parameter are (a) sea surface height anomaly (SSHA) from the available altimeters, (b) sea surface temperature (SST) from AMSR2 (**A**dvanced **M**icrowave **S**canning **R**adiometer **2**) and the climatological values of OHC700. The artificial neural network techniques, for the estimation of Tropical Cyclone Heat Potential, is followed in the estimation of OHC700.

This parameter is estimated on a daily basis from 2002 to present with a one week time delay.



Atmospheric Products

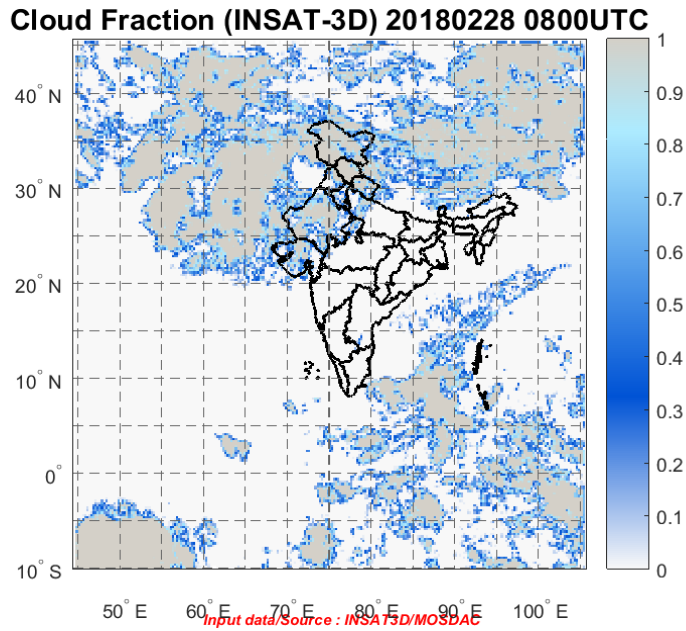
S. No.	Geo Physical Dataset	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
1	Cloud Fraction	KALPANA/VHRR & INSAT-3D/Imager	-10 °N-45.5°N; 44.5°E-105.5°E	Sep 2008 Onwards	0.25 °x0.25 °	Half Hourly	~2-4MB
2	Planetary Boundary Layer Height	SNPP / CrIS	05°N -40°N; 50°E-110°E	Sep 9, 2014 onwards	0.25 °x 0.25 °	Daily 7Days Monthly	~200 - 300KB
3	Derived Tropospheric Ozone	Aura/OMI& MLS	0º N-40º N 60º E-100º E	2010 Onwards	1.0 °x1.0 °	Daily	~1.5MB

Cloud Fraction

Cloud cover plays an important role in regulating the amount of energy that reaches the Earth from the Sun as well as the amount of energy that the Earth reflects and emits back to space. Changes in cloud cover will change the balance in Earth's energy budget. Any such change would change air temperatures and weather patterns.

Cloud Fraction is derived from the cloud cover product generated using the radiance and reflectance measurements from the thermal infrared and visible channels respectively along with water vapour channel from Very High Resolution Radiometer (VHRR) onboard Indian Geo-Stationary Satellite Kalpana-1 and INSAT-3D.

Using the methodology, Cloud fraction and cover has been generated, at an interval of half-hour, from September 2008 using Kalpana-1 and from October 2016 using INSAT-3D as well, at a spatial resolution of 25km. These products have been validated with ground-based data as well as with other satellite data (*Shivali et al.*, IJRS, 2018).



Planetary Boundary Layer Height (PBLH)

Planetary boundary layer (PBL) is the lowest part of atmosphere, which is directly influenced by surface forcings over short time scales. It is the region where significant transfer of energy, momentum, and mass between earth surface and atmosphere occurs. Planetary boundary layer height (PBLH) is an important parameter for PBL characterisation and also for evaluation of climate, weather and air quality models.

Planetary Boundary Layer Height (PBLH) over the Indian land mass is estimated using vertical profiles of temperature and relative humidity from Cross track Infrared Sounder (CrIS) onboard Suomi-NPP, through integration of five different methods, by considering vertical gradients of potential temperature, virtual potential temperature, relative humidity, refractivity and specific humidity (*Prijith et al.*, RSL, 2016).

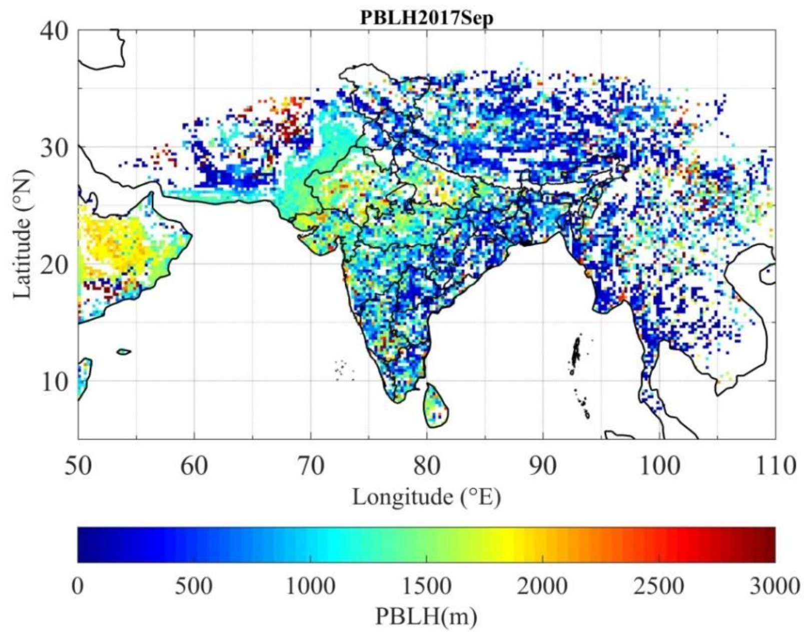


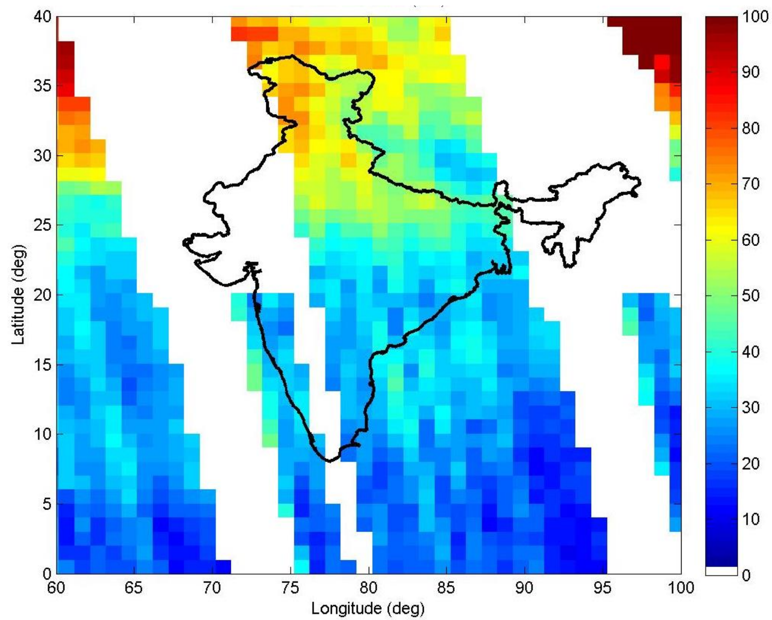
Fig: Daytime PBLH over the Indian landmass during Sep 2017, estimated through the integrated approach, using atmospheric profiles from SNPP-CrIS soundings.

Daily, 7day and monthly mean PBLH data from Sep 01, 2014 onwards is available on the NICES portal of NRSC.

Tropospheric Ozone

Ozone (O_3) is a reactive oxidant gas produced naturally in trace amounts in the Earth's atmosphere. It is concentrated well above the surface in a layer called the stratosphere, between 10 and 50 km and protects humans and other organisms against ultraviolet (UV) radiation from the sun ('good' ozone).

Ozone is also formed in the troposphere by lightning discharges and by the action of sunlight on mixtures of hydrocarbons and oxides of nitrogen. Some stratospheric ozone is also transferred to the surface by vertical circulation. Elevated concentrations of ozone at ground level, lead to respiratory effects in humans ('bad' ozone). Hence continuous monitoring of tropospheric ozone (TO) is essential.



Tropospheric Ozone (DU) -7 Mar, 2018

TO, an essential climate variable is derived from satellite sensors namely, from Ozone Monitoring Instrument (OMI), Microwave Limb Sounder (MLS) and Total ozone Monitoring Spectrometer (TOMS) using Tropospheric Ozone Residual Technique (Mahesh et al., 2015, IJRS). Using multiple satellite sources, daily TO over the Indian region is derived from 2010 onwards.

Ref- NRSC Document No: NRSC-ECSA-ACSG-APR-2016-TR-833

Cryosphere Products

S. No	Geophysical Products	Satellite/Sensor	Coverage	Availability	Resolution		File Size
					Spatial	Temporal	
1	Snow melt and freeze	Oceansat - 2 / OSCAT	Indian Himalayas	Jan 2000 to Dec 2013	2.225 km	Monthly	~100KB
2	Snow Cover Fraction	Resourcesat -2 / AWiFS	Himalayan Region	March 2014 Onwards	3'x3'	Fortnightly	~20KB
3	Himalayan Glacial Lakes & Water Bodies	Resourcesat -2 / AWiFS	Himalayan region of Indian river basins	Jun to Oct 2011 to 2013	1:250,000 scale	Monthly	~150KB
4	Snow Melt and Freeze	Oceansat - 2 / OSCAT	Antarctica	Jan 2001 to Feb 2016	2.225 km	Daily	~100KB

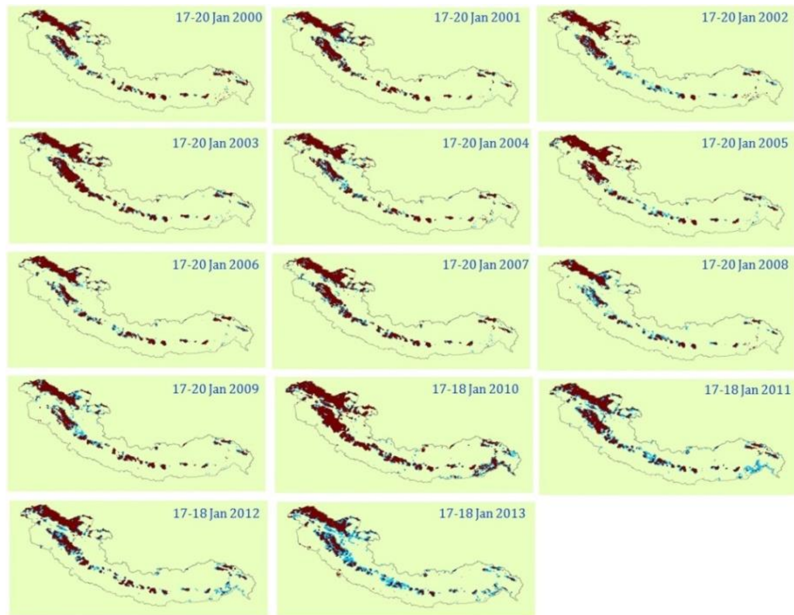
The cryosphere, comprising snow, river and lake ice, sea ice, glaciers, ice shelves and ice sheets, and frozen ground, plays a major role in the Earth's climate system through its impact on the surface energy budget, the water cycle, primary productivity and sea level. Generally in-accessible geographic areas and the harsh prevailing conditions of extent and distribution of different cryospheric components make the ground truth collection a difficult task. Remote sensing with its capability to view and monitor in-accessible areas in number of multispectral channel, spatial and temporal resolution provide a powerful and useful tool to study cryosphere.

Snow melt / freeze in Indian Himalayas using scatterometer data

nrsc

The study utilises Ku band scatterometer data from OSCAT on board 'Oceansat-2' and Seawinds data onboard QuikSCAT which are 13.6 GHz active microwave scatterometer and operate in dual polarisation mode of HH and VV providing alternate day coverage of the World. Enhanced resolution daily images at 2.25km resolution for HH polarisation were used in conjunction with AWS data for the period of January 2000 to December 2013.

A drop in σ^0_{HH}, which coincides with a positive temperature window indicating freeze (or melt) conditions. Normalised radar backscatter is sensitive to the water content of snow. With the increase in the liquid water content in the snow, there is a sudden decrease in the backscatter from radar. This is the basis of melt detection. The cyclic behaviour of snow is utilised in identifying melt / freeze status. Melt / freeze status is important in snow melt runoff estimation, energy balance studies and snow avalanche studies.



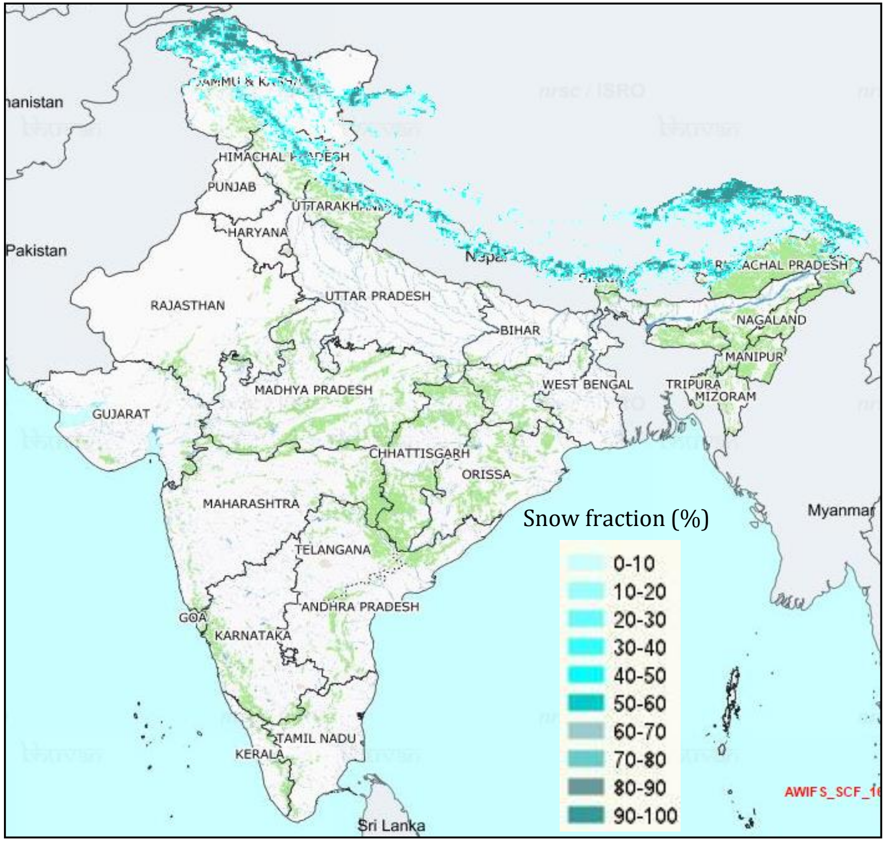
Snow melt and freeze status (For 17 Jan 2000 - 2013)

Satellite Derived Information on Snow Cover Fraction

Quantifying and attributing the spatio-temporal changes in snow cover are essential for meteorological, hydrological, ecological, and societal implications.

Snow cover is dynamic in nature and melts based on local temperature variations in different time periods. Satellite sensors can provide synoptic coverage at frequent intervals which facilitates mapping, monitoring of dynamics of snow cover. Automated Snow Cover Extraction (ASCE) Algorithm developed is used for quick processing of satellite data and extraction of Snow Cover Area (SCA). Further Snow Cover Fraction (SCF) as fraction of snow cover area over 3'x3' grid area was estimated using AWiFS data and MODIS data.

Data available: 2014 – 2016 (Fortnightly)



Snow Cover Fraction (%) 3'X 3' Grid

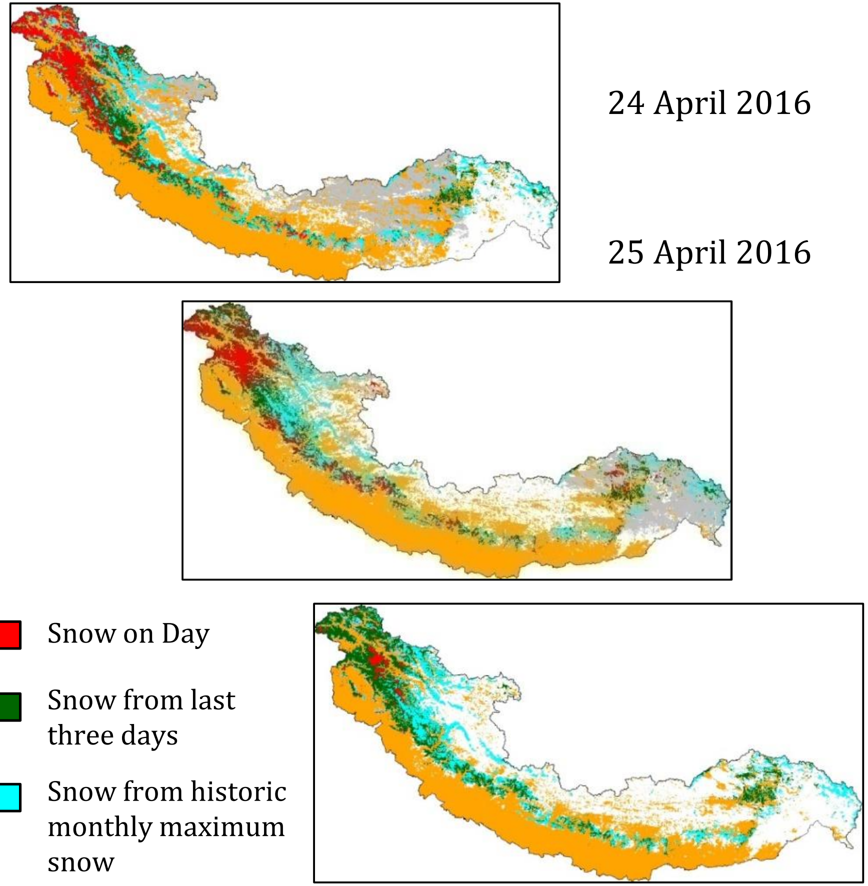
Satellite Derived Information on minimum cloud, maximum possible daily snow cover map

Daily extent of snow cover is of importance to variety of applications, viz., snow melt runoff, energy balance, etc. A maximum possible snow cover after elimination of clouds is the objective of this project.

The analysis includes derivation of snow cover and cloud map using NPP Suomi data at resampled resolution of 1 km presently. To reduce the cloud cover, a methodology is adopted where previous three days NPP Suomi derived snow cover data along with historical possible snow cover data (based on the analysis of 2002 – 2015 MODIS 8 day composite data) is used.

Output planned: Daily output from January 2016

Resolution: 1 km



24 April 2016

25 April 2016

26 April 2016

Snow on Day

Snow from last three days

Snow from historic monthly maximum snow

Snow free area

No data

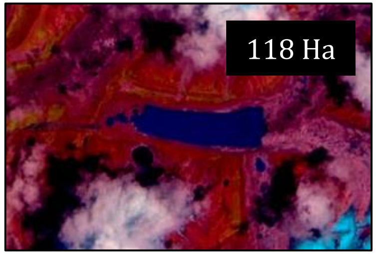
Cloud

Himalayan Glacier Lakes & Water Bodies

Glacial lakes are common in the high elevation of glacierised basin. They are formed when glacial ice or moraines impound water. These lakes normally drain their water through seepage in front of the retreating glacier. Flash floods caused by the outburst of glacial lakes, called as Glacial Lake Outburst Flood (GLOF), are well known in Himalayan terrain, where such lakes are formed due to landslides. Satellite remote sensing based mapping and monitoring of the glacial lakes and water bodies, covering Indian Himalayan region, is taken up. 415 glacial lakes area > 50 Ha & 62 with area between 44 and 50 ha are mapped during June to October every year.

Outputs: 2009 – 2016 (June to October) Monthly

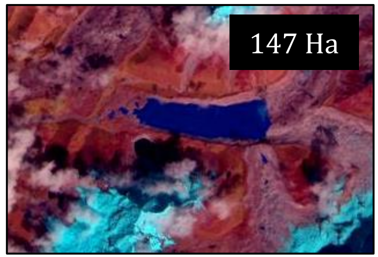
Source: AWiFS data



Sentinel-2 of 11-Aug-2016

RS2 AWiFS of 01-Sep-2016

Imja Lake in Himalayas, Nepal



Sentinel-2 of 10-Oct-2016

RS2 AWiFS of 14-Oct-2016

Acknowledgements

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