ISSN : 0972-642X

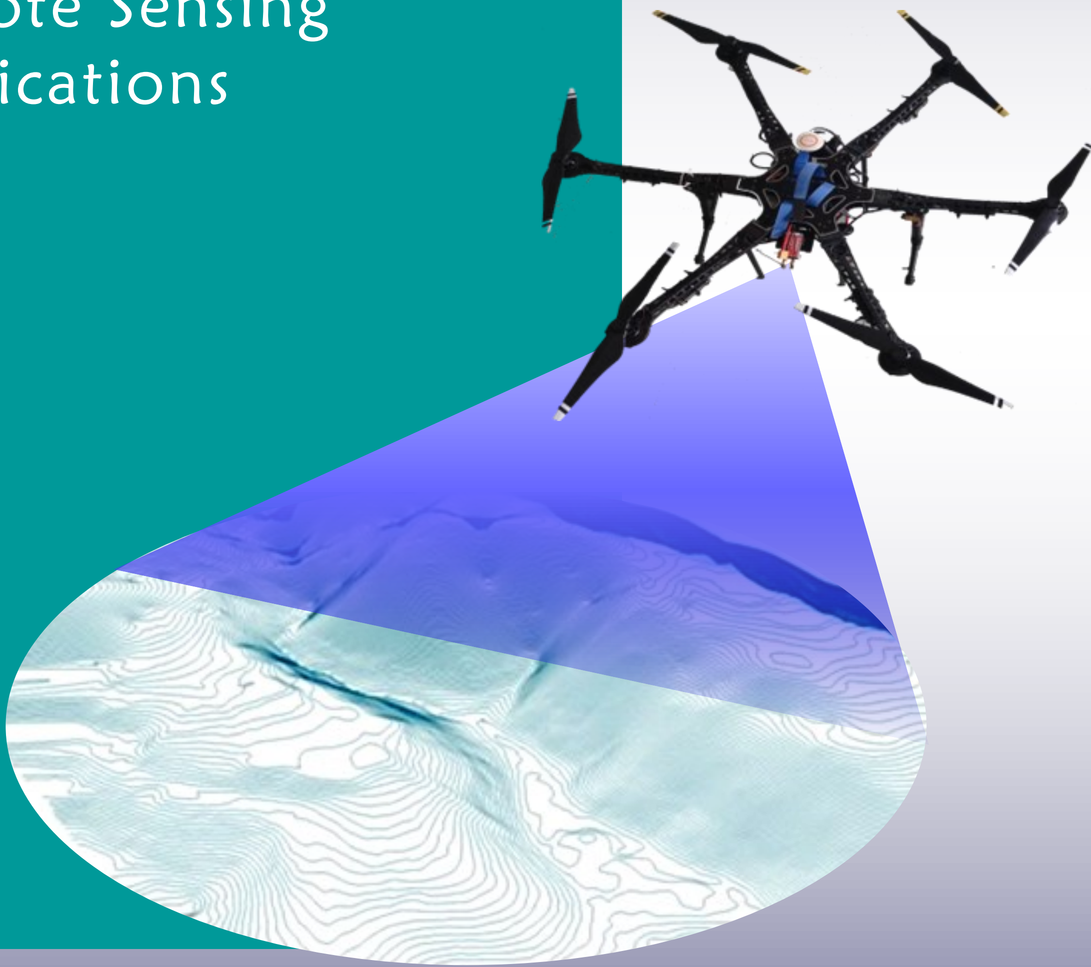
ISG NEWSLETTER

Vol. 23, No.2-4 & Vol. 24, No.1 & 2

June, 2018

Special issue on

Advancements in Remote Sensing Applications



INDIAN SOCIETY OF GEOMATICS

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ISG NEWSLETTER

Vol. 23, No. 2-4 & Vol. 24, No. 1 & 2 **June, 2018**

In this Issue

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Editorial Board – ISG Newsletter

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Editorial

Special Issue : "Advancements in Remote Sensing Applications"

From the Editor's Desk

Dear Members,

This issue of Indian Society of Geomatics (ISG) is bringing out a special issue of ISG Newsletter on "Advancements in Remote Sensing Applications, with a view to covering a wide gamut of remote sensing applications which has advanced through the last decade in leaps and bounds.

In order to get the flavours of the different applications we have compiled invited articles from several stalwarts in their respective areas. The applications of the coveted UAV based remote sensing in the NE region of India, has been covered by Dr P L N Raju and his team. 'Amul, the taste of India' has been roped into the domain of space and remote sensing applications by Dr. Sujay Dutta, and it makes very interesting reading indeed. Solar Calculator has been acknowledged by the ministry of power, as a potential application tool for monitoring and harnessing the natural solar power. This topic has been covered by Dr Shashikant Sharma. Whether it's optical, hyperspectral or microwave remote sensing, no application will work properly without proper calibration; and Shweta Sharma and team have given a beautiful insight into the calibration strategy for SAR with a view to establishing a pan India network for the upcoming NISAR mission, and ISROs SAR missions. We felt that special attributes should be given to the women scientists of ISRO, from SAC and NRSA, who have braved the harsh environment of Antarctica, and carried out extensive research in their domain. The narration has been carried out in this domain by Dr Rajashree Bothale and Team ,Women of ISRO. Kudos to them, and a must read for all our readers.

Finally, no cake is delicious without the icing on it. Hence, we have done a special interview with one of the greatest stalwarts in the field of Remote Sensing Applications, in India, Dr Shailesh Nayak, to make this Newsletter complete.

I thank the contributors and columnists for their cooperation and the editorial team for doing an excellent job.

I would request the readers to kindly send their valuable feedback, which we will try to put in our subsequent publications of the Newsletter, and this will surely help us in assessing our strengths and weaknesses.

Happy reading.

AMisra

Arundhati Misra
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जय हिन्द

सत्यमेव जयते

तपन मिश्रा
निदेशक
Tapan Misra
Director

M E S S A G E

Remote Sensing Applications in India spanning more than three decades paved the way for a variety of life changing scenario in the sub-continent. The geo-synchronous satellites with high temporal sampling, carrying the visible, NIR, imager and sounder data sets, provided the most crucial and timely meteorological forecasts which saves life and livestocks and also aids in planning. This was followed by the polar remote sensing satellites with high spatial resolution data which led to a whole gamut of applications for societal use, including agriculture, forestry, geology, coastal bathymetry, hydrology to name a few.

Observations from remote sensing are not only being used to address the planning and management of natural resources in our country, but are also providing valuable information on climate change in terms of occurrence of extreme events, glacier retreat, increase in air pollution, sea level rise, depletion of ground water, land deformation etc.

Remotely sensed data have grown in scope and variety (Big Data), and huge amount of data presents a new challenge for developments in processing, storage and dissemination techniques. The Big Data concept is characterized by the volume, velocity, veracity, value and visualization. The development in cloud computing technology in recent years has helped in required intensive computing. Retrieval of physical, chemical and biological properties of the object is a challenging task as it requires multidisciplinary knowledge from sensor technology, computation science and application skills.

Improvements in space technology have led to demand of newer applications, better calibration, and field scale verifications. Availability of Unmanned Aerial Vehicle (UAV) has added newer dimension to high resolution remote sensing and field scale assessment. Establishment of Corner Reflector network is an important area for accurate calibration of SAR sensors and its data, and for generating quality products at global level.

This issue of ISG Newsletter has brought out a comprehensive series of articles encompassing the applications being developed in ISRO, in various fields of remote sensing.

I hereby congratulate the Editor and her Editorial Team for bringing-out this issue of ***ISG Newsletter on "Developments in Remote Sensing Applications"*** highlighting new applications of remote sensing such as for fodder assessment and its use in Dairy sector, Antarctica expedition, role of UAVs and corner reflectors, etc. I hope the Team will continue their efforts in communicating recent developments and innovative ideas for the benefit of members in future issues of Newsletter.

Place: Ahmedabad
Date: 25 June 2018

(तपन मिश्रा) / (Tapan Misra)
President, ISG

An Interview with Dr Shailesh Nayak

Dr. Shailesh Nayak is currently Director, National Institute of Advanced studies. He was Distinguished Scientist during 2015-2018 and Secretary, Ministry of Earth Sciences, Government of India, during August 2008-2015, and provided leadership for programs related to earth system sciences. He obtained PhD degree in Geology from the M.S University of Baroda in 1980. He has been credited with launching many research programs related to monsoon, air-sea interaction, changing water cycle, atmospheric chemistry, coastal vulnerability, climate services, etc. with US, UK, Germany, Japan, Australia, Norway, South Korea. He had set up HPC system having 1.1 Peta flops capacity for weather and climate research and operations. He had restructured meteorological activities in the country and thus improved weather and hazard related services.

ISG: Sir, ISG is extremely fortunate to have an eminent personality like you, for the interview session. We, the Remote sensing fraternity, know that you are one of the pioneers of Remote Sensing Application Programmes, in India. Please share some of your experiences with us about the scenario when the Indian remote sensing application program was in its budding stage?

Dr S. Nayak: During initial period, in late seventies, the idea was to demonstrate utility of remote sensing for certain applications such as agriculture, land use planning, groundwater targeting, etc. The important aspect was to carry out such projects with the concerned state or central government departments. In this way, we can built capacity, as well as the information or products generated, can be used in resolving issues. I can give an example of the project on Idduki district, Kerala. The project was based on data collected from aerial platform. In this project, it was envisaged to prepare land use plan for the district, and the Kerala State Land Use Board (SLUB) was our collaborator. We have involved officials in all aspect of the project, viz. planning for aerial flights, conducting aerial survey, interpretation and analysis of aerial photos (CIR and B/W stereo photos), map preparation and compilation, reports preparation and ultimately preparing Land Use Planning Atlas. In the process, we transferred all know-how to SLUB and the proposed plans were implemented. Later on SLUB carried out aerial survey for other districts and prepared land use plans for those districts in Kerala. So the idea was to empower concerned agencies to produce data as per their requirement and institutionalize use of remote sensing while we can continue to carry out further research.

ISG: Sir, in your view how has been the journey of application development in the late 80's and early 90's and the development so far?

Dr S. Nayak: The late 80's and early 90's were times when two major programs were undertaken in ISRO. One was utilization of Indian Remote Sensing (IRS) programs where emphasis was on development of techniques/ algorithms to utilize IRS data for various applications, such as crop forecasting, identification of forest types, monitoring of coastal environment, marine fisheries, etc. At the same time many national level projects were launched where methodologies were already developed and were scaled up at the National level. These projects were related to groundwater, wasteland mapping, potential finishing zone, coastal mapping, etc. However, in all these projects, the emphasis was always on to transfer of technology to the concerned institutes. After the nation-wide forest mapping was carried out, the technology was adopted by the Forest Survey of India (FSI). Now the Forest Survey of India regularly publishes the state of Forest, every two years, since 1987. Over the years, these data sets have become very valuable to understand changes, both loss and gain of forest cover.

ISG: All the earlier Indian missions have been realised with limited resources, all the learning was on the job. What were the challenges faced during the development of certain applications particularly for ocean applications?

Dr S. Nayak: Fortunately, we have sufficient resources as far as Ocean applications were concerned. The then Department of Ocean Development (DoD) had provided sufficient grant to develop various application packages, viz., sea state, coral mapping, fisheries etc. The major challenge was to get research ship-time to conduct various experiments. We were getting ship-time about three weeks in a year, which was grossly inadequate, as we had several projects under DoD program. So many times, we were forced to hire small boats, fishing vessels, etc to conduct various experiments. But these vessels were not having adequate facilities, such as CTD, so we were able to measure only few parameters. So we were unable to understand all processes to operating in a region. Also at that time, the National Institute of Oceanography (NIO) was the only institute working on similar problems. Though NIO has supported in all such endeavours, research personnel were not adequate. Even today, we have few institutes conducting oceanographic research. Though ISRO has a strong and continuing satellite program, the scientists involved developing algorithms and various geophysical products are limited.

ISG: There must have been anxious moments when you were to receive the first day images from Oceansat? Can you share your experiences?

Dr S. Nayak: Yes, of course. At that time, ocean colour monitor on the Oceansat-1, was the only ocean-colour satellite having high spatial resolution, 360m. The sea WiFs, other ocean colour satellite, was having 1 km. The 360m spatial resolution was chosen to observe chlorophyll patterns and quantify them. Chlorophyll generally occurs as patches, the smallest could be ~300 m in length. Hence, when the first image came we could clearly see beautiful chlorophyll pattern first time from space and we were all thrilled.

ISG: 'Harnessing Space technology for societal benefits' is the main motto behind Indian Space Programme. Which are the most significant areas, in which you think your work made a great impact on the nation?

Dr S. Nayak: We need to translate our knowledge and understanding about various earth system processes into products and services for the societal benefits. The first one such was the development of techniques/algorithms for use of satellite data in understanding of coastal resources and processes. Information on various coastal landforms, shoreline changes, high and water lines, coastal land use, coral reef, mangroves, sediments and their movements, etc was generated and these were used as benchmark databases for coastal zone management. These large databases were used for many applications such as brackish-water, aquaculture site selection, assessing health of mangroves and coral reefs, identifying areas under erosion and deposition, and many others. However, the most important use of these maps was in implementing the Coastal Zone Regulation (CRZ) Notification which prohibited or restricted certain activities in the zone between high and low tides as well as upto 500m from high tide line. The coastal maps, for the first time provided uniform and reliable data to the entire Indian coast. These maps were also accepted as the record of the ground conditions by the Courts in India and many legal issues were resolved using these data sets. Actually about 1000 maps were submitted to the Supreme Court in 1996 by the Ministry of Environment and Forest (MoEF) as a record for implementing CRZ notification. These maps were provided to MoEF by the Space Applications Centre (SAC). SAC continued to supply these maps to many state governments and industries for implementing projects. These contributions also published as an entire chapter in the highly acclaimed, the 'Manual of Geographic Information Systems, published by the American Society of Photogrammetry. Today, the use of satellite data in CRZ implementation is mandatory. MoEF has also set up on Institute namely National Centre for Sustainable Coastal Zone Management in Chennai to provide support to MoEF.

Another unique applications was to locate potential fishing zones (PFZ). This application uses satellite-based sea surface temperature as an indicator of the environment and ocean colour or chlorophyll as an indicator as food. Integration of these two data sets along with various physical phenomena such as upwelling, fronts, etc. provide information on PFZ. This information along with sea state conditions is provided to fishermen throughout the coast using all available communication media. These advisories immensely helped fishermen in saving fuel and searching time. This application benefited fishermen economically and increased their safety. Today no fishermen goes to sea without this advisory. The annual benefit as computed by the National Council of Applied Economic Research is Rs. 34,000 crores. This technology was transferred to the Indian National Centre for Ocean Information Services (INCOIS) who currently provides these advisories to fishermen daily.

ISG: ISRO has had International collaboration in Earth Observation & Planetary Scientific explorations. In your opinion, what is the long term benefit which our country is going to get from the planned Indian planetary missions?

Dr S. Nayak: Since civilization began, human beings have wondered about the secrets of solar system and universe. We find references in our Vedic literature about their quest for knowledge of universe. In my view, Planetary missions have facilitated to advance our knowledge about origin, evolution of our solar system and possibility of discovery of life. It also helped to advance technologies about space-craft and robotic engineering.

ISG: Sir, what is your vision about the global warming and role of Indian Scientists in broader policy making activities in International forums?

Dr S. Nayak: Global warming is unequivocal as evidenced by global data sets on atmosphere and oceans. The data collected by the Indian Meteorological Department over the Indian sub-continent clearly indicates warming of atmosphere during last 150 years. The sea level rise, retreat of glaciers, loss of sea ice, etc. are other evidences of global warming. We need to focus on developing models to understand its likely impact on water resources, agriculture, forest and bio-diversity, natural hazards and monsoon, etc. Internationally there is also an attempt to shift focus from increase in CO_2, which is main reason of climate change which is essentially increased due to industrialization by developed countries to areas such as methane emission from paddy cultivation, black carbon, biomass and crop-burning, air-pollution, etc. These issues are more prevalent in developing countries. We should carry out scientific studies to develop models to show that these activities do not impact on global warming on a long term. We also need to build climate services similar to weather services.

ISG: You have played a pioneering role in the development of Ocean Colour Monitoring, ICZM, PFZ & CRZ applications and development of Tsunami warning systems. What would be your advice on the future course of oceanographic applications in India?

Dr S. Nayak: We need to focus on likely impact of sea level rise on coast, especially on infrastructure and population, systematic recording of marine biodiversity and changes and regime shift of fisheries such as Sardine and Mackerel, harnessing ocean thermal energy, etc. We also need to understand role of ocean, especially Indian Ocean on modulating climate. The major areas of research are as defined by the International Indian Ocean Expedition-2.

- Boundary Current dynamics, upwelling variability and ecosystem impacts,
- Monsoon variability and ecosystem response
- Circulation, climate variability and change
- Extreme events and their impact on ecosystems and human populations
- Geological, physical, biochemical and ecology of the Indian Ocean
- Data and information management

ISG: You are fellow of many renowned national and international Scientific Societies and you have given very active services to many of these societies. From your vast experience, can you kindly elaborate about the direction in which scientific societies in India should move?

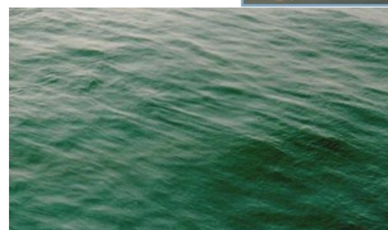
Dr S. Nayak: The most important function of the Scientific Societies is to communicate scientific achievements and their importance in improving quality of life of various stakeholders such as policy makers as well as common people. Second, it should provide a platform for scientists, researchers and officials to interact and discuss about their findings and help in advancement of science. Third, to collaborate with international scientific societies in the respective field to showcase our achievements as well as to learn from them. Indian scientific societies need to join with other similar societies and establish a mechanism to jointly address issues related, agriculture, ocean, mineral resources, energy, water resources, climate change, hazards, etc. In this regard, the societies dealing with geoscience have come together and formed the Federation of Indian Geoscience Association (FIGA) to address larger issues. I think ISG and ISRS should join this federation.

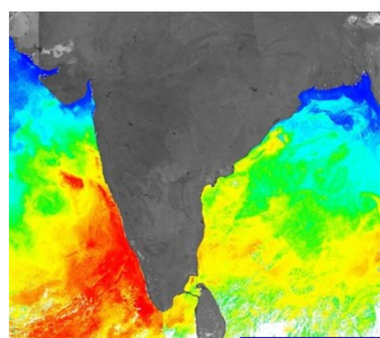
ISG: Now something on your personal journey and few questions regarding your immensely successful career. You have been an institution builder and remain instrumental in making many positive changes at various capacities. How do you see your journey so far, from Group Director-SAC to Director-INCOIS, Secretary-MoES; Chairman-Earth Commission, and now as Director-NIAS?

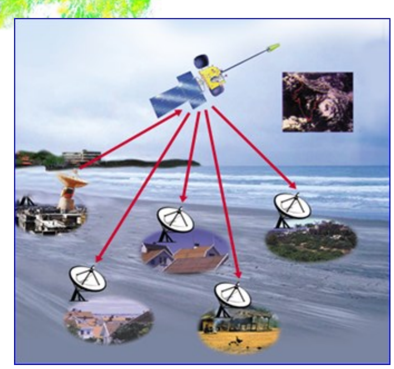
Dr S. Nayak: It was truly fantastic journey. I learnt that motivation, creativity and team-building are most important for success. We need to convert our scientific knowledge into products and services for common man, such as farmers, fishermen etc. This gives immense satisfaction. At NIAS, I am looking forward to integrate natural science with social science, so that we can advance our knowledge to achieve sustainability.

ISG: Sir, *thank you very much for sparing your time for ISG Newsletter. We* would finally request you to give your advice to our readers in order to enable them to excel in their respective domains.

Dr S. Nayak: We need to have passion in whatever we do. The passion combined with up-to-date knowledge and hard work is vital to succeed in life.







Antarctica expedition and role of Indian Women Space Scientists

Rajashree V Bothale, Mangala Mani, Padmavathy Chandrasekharan, Kiral Ghodadra*, Purvee Joshi*, Megha Maheshwari**, Deepika Roy*, Lakshmipriya Prusty* & Ankitha Reddy

National Remote Sensing Centre, Hyderabad, * Space Applications Centre, Ahmedabad, ** URSC, Bangaluru

Abstract

Antarctica (The land of uncertainty), the coldest, driest, farthest, highest continent on the Earth, poses challenges to all who wish to go there and work. Situated in the Southern hemisphere, containing the geographic south pole, surrounded by the Southern Ocean, Antarctica has two Indian permanent station named Maitri and Bharati. These stations are frequented by members of Indian Scientific Expeditions, of which there have been 37 till date. Women scientists of Indian Space Research Organisation have visited Antarctica under various expeditions and worked at Maitri & Bharati stations for a variety of projects. In-spite of the harsh environment and other challenges, each member completed the task at hand. This article is a compilation of the work carried out and the memories of 9 ISRO women scientists who went to Antarctica from the 32nd expedition onwards and spent from two months to a year in the continent.

INTRODUCTION

Antarctica (70^0 to 90^0 South) is the coldest continent on Earth where average temperatures along the coast & inland are -10^{0}C and -60^{0}C. The lowest recorded temperature without the effect of wind chill was observed to be -89.2^{0}C at Vostok. With an area of 14 million sq. km, it is also called a pulsating continent as its size keeps on increasing and decreasing during different seasons due to the formation of fast ice in winter. About 98% of the continent is covered with glacial ice that reaches to an average of 2450m with maximum being 4.5 km. Always nourished by snow and falling ice crystals, the ice-sheet flows outwards from the interior. Antarctica is a desert, with annual precipitation of only 200 mm in the form of snow along the coast and far less inland. Small hillocks and mountain ranges make the remaining 2% of the continent. It is the windiest continent as wind speeds can reach upto 300 km/hr and blizzards can rage for days together, rendering visibility to a few meters. More than 70% of the World's fresh water resources are available in this continent in frozen form. India became a member of the Consultative Committee of the Antarctic Treaty on September 12, 1983 and a member of Scientific Committee on Antarctic Research (SCAR) in September 1984. India created history when its first scientific expedition landed in Antarctica on 16 January 1982. Since then, scientific expeditions have been launched every year. The first Indian Station was constructed at Dakshin Gangotri ice shelf in 1983. The station got buried in ice and was abandoned in 1989. The second station "Maitri" was constructed (1988-89) nearly 100 km away on an ice free hillock of Schirmarchar Oasis, Central Drauning Maud Land, East Antarctica at the location 70^0 46´ S latitude & 11^0 44´E longitude. The third Indian Antarctic Station, Bharati (Location: 69^0 15' S, 76^0 25' E) became operational since March 2012 at Larsemann Hills, East Antarctica which is nearly 3000 km away from Maitri station (Figure 1).

INDIAN SCIENTIFIC EXPEDITION TO ANTARCTICA (ISEA):

The Indian Antarctic Program is a multi-disciplinary, multi-institutional program which is controlled by National Centre for Antarctic and Ocean Research (NCAOR), Ministry of Earth Sciences, Government of India.

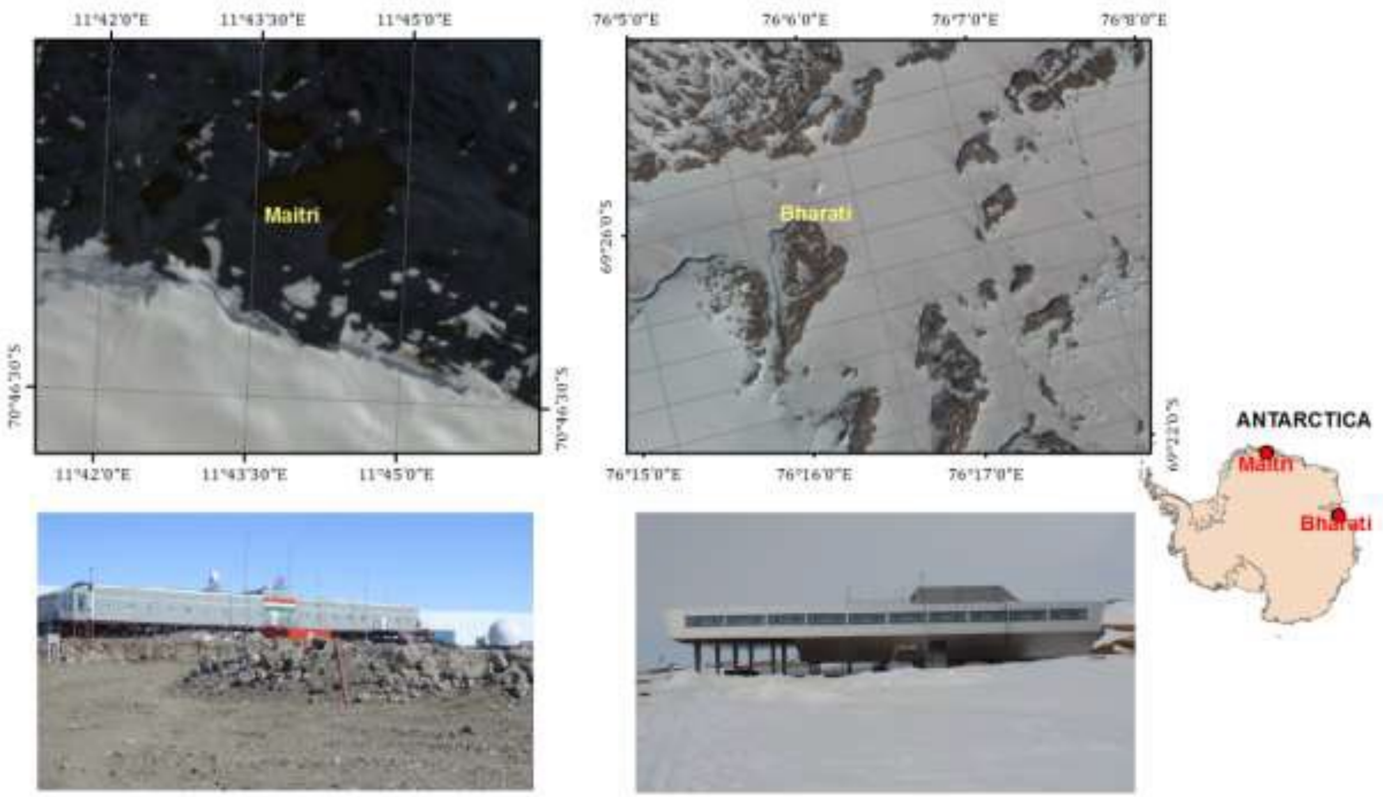


Figure 1: Location map of Maitri and Bharati station, Antarctica

The first Indian expedition to Antarctica landed in Antarctica on 16th January, 1982. Since then expeditions have been launched every year. NCAOR invites project proposals on various themes, viz., meteorology & atmospheric sciences, biology & environment sciences, human physiology & medicine & earth science & glaciology, etc. Apart from this, ISRO has ISRO Ground Station Establishment (AGEOS) at Bharati, Antarctica which was established in the year 2012-13. ISRO women scientists have been participating in ISEA since the 32nd expedition. Apart from a few Junior Research Fellows, a total of 9 women scientists have participated in the programme. Table below shows the list of participants with their project and expedition details.

S No	Name	Organisation	ISEA / Year	Project
1	Ms Megha Maheshwari	URSC (Ex SAC)	ISEA 32/2012-13	Polar ENvironment processes, Global Warming effects and their INdian teleconnection
2	Ms Padmavathy Chandrasekaran	NRSC	ISEA 32/2012-13	Installation of AGEOS at Bharati
3	Ms Deepika Roy	SAC (Ex NRSC)	ISEA 32/2012-13	Installation of AGEOS at Bharati
4	Dr Rajashree V Bothale	NRSC	ISEA 35/2015-16	Study of snow melt/freeze dynamics in Antarctica using space based and ground based observations.
5	Ms Mangala Mani	NRSC	ISEA 36/2016-17 -Winter	Operations and Maintenance of AGEOS at Bharati Station
6	Ms Kiral Ghodadra	SAC	ISEA 36/2016-17	Validation of parameters of Antarctic Ice Dynamics extracted from Indian Remote Sensing Data
7	Ms Purvee Joshi	SAC	ISEA 36/2016-17	Validation of parameters of Antarctic Ice Dynamics extracted from Indian Remote Sensing Data
8	Ms Ankitha Reddy	NRSC	ISEA 37/2017-18 Winter	Operations and Maintenance of AGEOS at Bharati Station
9	Ms Lakshmipriya Prusty	SAC	ISEA 37/2017-18	Validation of parameters of Antarctic Ice Dynamics extracted from Indian Remote Sensing Data

PREPARATIONS TO BE A MEMBER OF THE EXPEDITION:

In order to be a member of the expedition, one needs to be medically and physically fit. Each member of the team has to undergo a strict medical examination at AIIMS, New Delhi. Members joining the wintering team have to undergo psychological tests too. After clearing the medical test, each member has to go to Mountaineering and Skiing Institute (M&SI), Auli, Uttarakhand and Badrinath for 12 days of physical endurance training. The training not only improves endurance, it also prepares members against unforeseen circumstances which might happen at Antarctica. Rock climbing, working on ice, learning about ropes and knots, pitching tents, walking long distances with load, etc., are some of the tasks and exercises carried out at the training centre. Another objective of this process is to see the compatibility of the person in the team as team work is very important in Antarctica. Before departure another training is given at Goa about firefighting and practical problems/solutions.

Figure 2: Training at Auli, Badrinath & Goa

JOURNEY TO ANTARCTICA:

From Goa, the expedition goes to Cape Town, South Africa, after which members either fly to Novo runway, Antarctica, which is near the Maitri station, or board a ship that sails from Cape town towards Bharati. Those who go to Maitri can either work there or take a small feeder flight to Progress runway which is near Bharati. Apart from carrying supplies to Indian stations, the ship is also used to carry out experiments.

Figure 3: Modes of transport

SCIENTIFIC WORK AT ANTARCTICA:

Installation, operation & maintenance of AGEOS

- An NRSC/ISRO women team participated in the installation of AGEOS at Antarctica. This station acquires data from Indian satellites. Presently it tracks about 14 IRS missions per day with 60 passes and downloads data volume of 1.2TB/day. The facility became operational in 2013 when connectivity was established with the mainland after installation of antennas.

The installation had many technological challenges including systems working at extremely low temperatures and high wind velocity, remote configurability of remote components and planning for sufficient storage capacity. With tremendous requirement of higher data rates, forthcoming IRS missions are equipped with Ka-band systems. Therefore, a second antenna system (triband) has been installed at Bharati this year and commissioned primarily to support forthcoming IRS missions and also to serve as a redundant system for the existing terminal.

Figure 4: Installation of DCS antenna during 2012-13 and Triband antenna during 2017-18

The operation & maintenance of the AGEOS station is quite challenging. The team has to ensure 24x7 smooth functioning of system for real time pay load data acquisition, TTC support and data transfers. It is also a crucial station for Launch and Early Orbit Phase (LEOP) of new missions. The work demands complete attention, alertness, confidence and emergency-management skills. The team members have to stay for one year in the harsh winters of Antarctica.

Figure 5: Communications, TTC and PLD Systems & inside of Radome antenna

Validation of parameters of Antarctic Ice Dynamics extracted from Indian Remote Sensing Data:

- Space Applications Centre (SAC) has a long term project called Polar ENvironment processes, Global Warming effects and their INdian teleconnection **(PENGWIN),** which aims at studying different phenomenon of Antarctica and its connection with climate change.

The main objective of the project is to assess various polar region's phenomenon remotely using satellite data and modelling of ice sheet and sea ice related parameters. This is achieved through:

- Collection of weather data (wind speed, air pressure, air temperature) during voyage
- Collection of surface roughness over ice sheet and blue ice areas
- Measuring thickness of snow over land & sea ice using Ground Penetrating Radars (GPRs at frequency 400MHz, 500MHz, 1 GHz).
- Validation of glacier surface velocity derived through satellite data
- Collection of DGPS data on ice sheets.

Figure 6: Observations during voyage and on sheet ice

Figure 7: GPR survey on fast ice and sheet ice

Figure 8: DGPS station and survey

The reports published from the work are given here:

1. Megha Maheshwari, R.K.Kamaljit Singh, Jayprasad, R.Rajak, Sandip R Oza, and Raj Kumar, 2013, "Analysis of surface roughness from in-situ measurements using laser profilometer and comparison with SAR backscatter around Indian Antarctic stations", Scientific Report, SAC/EPSA/AOSG/OSD/SR/10/2013.
2. D. Ram Rajak, R.K. K Singh, Megha Maheshwari, Jayaprasad P., Sandip R. Oza, Javed M. Beg, Rashmi Sharma and Raj Kumar, 2014, "Sea Ice Advisory using Earth Observation Data for Ship Routing during Antarctic Expedition", SAC/EPSA/AOSG/SR/22/2014.
3. D. Ram Rajak, Jayaprasad Rajumar Kamlajit Singh, Megha Maheshwari, Sandip R Oza, Raj Kumar, 2014, "Preliminary Analysis of Data Collected During 33rd ISEA", Scientific Report, SAC/EPSA/AOSG/SR/03/2014.

Snow melt/Freeze analysis

NRSC, Hyderabad has an ongoing project for study of melt/freeze dynamics in Antarctica and sea ice characterisation using space based and ground based observations. The project aims at correlating ground based observations of snow depth, density, wetness and melt/freeze status with satellite based observations and building a database for future ISRO missions of scatterometer and other related satellites. To achieve these objectives, GPR was used to measure the depth of fast ice and the profile of sheet ice. Snow fork measurements were taken at different locations to measure density and wetness in order to understand/verify the variations in backscatter response and to correlate with field conditions.

Figure 9: GPR and snow fork observations

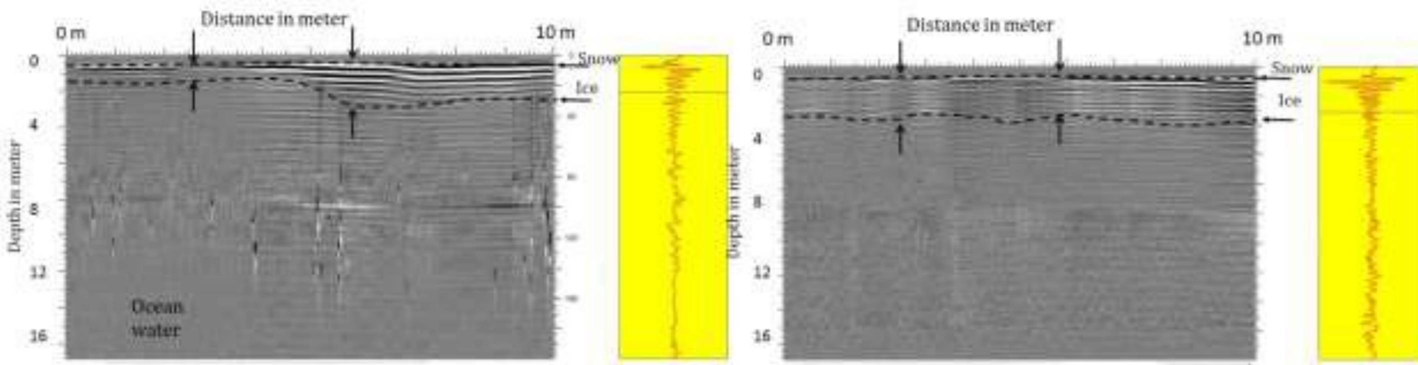


Figure 10: GPR profiles en route McLeod island from Bharati station

The publications from the work are given here:

1. Bothale, Rajashree, Anoop, S, Rao, V V, Dadhwal, V K and Krishnamurthy, Y V N (2017). Understanding relationship between melt/freeze conditions derived from spaceborne scatterometer and field observations at Larsemann hills, East Antarctica during austral summer 2015-16. Current Science, Vol 113 (4), August 2017, pp 733-742
2. "Response of Fast ice to Ground Penetrating Radar and backscattering coefficient from scatterometer in Larsemann Hills, East Antarctica" by Rajashree Vinod Bothale, S Anoop, Manne Gopaiah & Mehanaz Sherief – Under publication in Current Science

LIFE AT ANTARCTICA

Life at Antarctica is fun filled. The continent itself is beautiful and every one tries to live with Indian traditions. All the national events are celebrated with patriotism and fun in the company of Russian & Chinese team members who visit Indian stations. All Indian festivals including Diwali, Christmas, Eid, Holi are celebrated at the stations. Wintering members get to see the beautiful dancing auroras. The lucky ones see solar halos too. Each member performs galley duties, which also include cooking and cleaning. All Indian delicacies are made at stations.

Figure 11: Celebrations of National days and festivals

Figure 12: Aurora and Halo – Sky wonders at Antarctica

Figure 13: Cooking duties

A visit to Antarctica can not be considered complete without seeing the beautiful penguins. The 1 to 3 ft height Adelie penguins are most adorable creatures in Eastern Antarctica. Emperor penguins are also sighted near Bharati station sometimes. Seals, polar birds such as Skua, storm Petrels, etc., are also seen here.

Figure 14: Wild life at Antarctica

Figure 15: The beautiful Antarctica – Icebergs, Frozen icebergs, view from sky, Shivling near Maitri

CHALLENGES & EXPERIENCES

Antarctica is a beautiful continent but isa land of uncertainty due to its changing weather conditions. The weather can change from clear sky conditions to snow blizzards with very low visibility in a matter of minutes. The journey itself is quite challenging. People by ship travel from the roaring 40's to furious 50's to screaming 60's. The feeder flight en-route Bharati & Maitri can take from 8 hours to a few days to travel depending upon weather conditions. Wind chill effect often brings the temperature down to -25^{o}C even in summer causing difficulty in field work. Hidden crevasses also pose danger to field parties. The meteorological predictions are taken very seriously in Antarctica particularly by the people going to field. The working environment is not always favourable in Antarctica. The extreme environment, such as high winds, extremely cold temperature, enhance the level of difficulties. In Antarctica resources are very limited and one should be very careful at each step. One small mistake can lead to a big accident there.

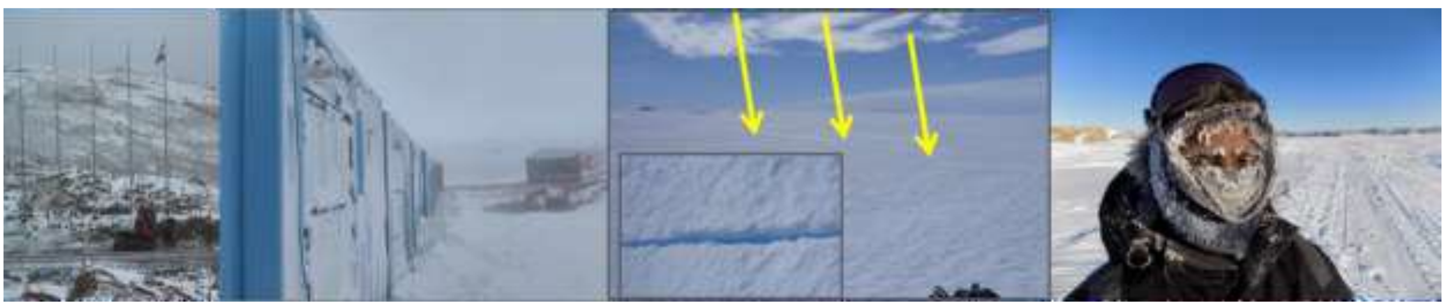


Figure 16: Challenges in the form of changing weather, crevasses, blizzards, inhospitable terrain

Staying for wintering itself is a challenge. There can be physical, emotional, medical and psychological issues amongst wintering members. Due to total darkness and biting cold, outside activities are restricted.

A lot of logistical tasks have to be performed by all team members irrespective of the gender. Tasks such as lifting heavy loads to shifting material, performing ship/station keeping duties to monitoring station parameters, etc., are done by expedition members even in rough Antarctic weather with heavy winds. Maitri, being an old Indian station, often lacks basic necessities.

Being a woman, it is quite challenging to live in a place where summer team members have to stay in containers, use sleeping bags & incineration toilets. In all, the journey to Antarctica is like dream come true for every one. Time and weather will cover the tracks of the explorer but the memories will be eternal.

ACKNOWLEDGEMENT

The authors wish to express gratitude to their respective Directors, Deputy Directors for providing the opportunity to participate in the Antarctic expedition. Thanks are due to NCAOR team for all the logistic arrangement, station leaders for the logistic support and team members of respective expedition for all the help.

Applications of Unmanned Aerial Vehicle (UAV) based Remote Sensing in North Eastern Region of India

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INTRODUCTION

Unmanned aerial vehicle - UAV popularly known as drone, is an airborne system or an aircraft operated remotely by a human operator or autonomously by an onboard computer. There are two broad classes of UAVs- Fixed wing and Rotary based. The fixed wing UAV can carry bigger sensors as payloads for longer distances with higher endurance and can fly during rough windy conditions. The rotary based UAVs are capable for takeoff and landing vertically, hover and perform agile manoeuvring to maintain a visual on a single target for extended periods of time. The fundamental advantage of UAVs is that they are not burdened with the physiological limitations and economic expenses of human pilots and Scientists can conduct research in much more flexible way (Everaerts., 2008). UAVs are cheaper, smaller and lighter than manned aerial vehicles. UAV operations are far less expensive than any manned aircraft and far more environmentally friendly as it generates less CO_2 and noise.

UAV based Remote Sensing (UAV-RS) has enabled the rapid collection of high resolution data over a region of interest and emerged as an efficient tool supplementing satellite based remote sensing. With the fast growing need for highly accurate and detailed observation data required in many applications such as environmental, agricultural and natural resources monitoring, Unmanned Aerial Vehicles (UAV's) has emerged as an efficient supplement to remote sensing data. Low altitude UAVs have seen significant growth in recent years, as they offer flexibility and rapidity of use and low operational cost. In addition, UAVs can be of great value in observations carried out in an environment that may be harmful or dangerous to an aircrew such as forest fire monitoring, landslides, Floods etc. (Réstas, 2006; Martínez-de Dios, 2006; Casbeer, 2006). There have been increased number of applications of UAV remote sensing such as agricultural monitoring and assessment (Herwitz et al., 2004, Anen and Nebiker et al., 2007, Handique et al., 2016), forest resource assessment including wildlife monitoring (Weissenteiner et al 2015, Vermeuleno et al 2013, Sarda-Palomera et al,. 2012), disaster management, large scale land use land cover mapping, 3D modelling etc. The huge amount of data, provided by UAVs, pose a new challenge in terms of processing, storage and transmission techniques.

This article focuses on the initiatives of North Eastern Space Applications Centre (NESAC) in the applications of UAV for the management and monitoring of natural resources and disasters and showcase a few recent studies carried out in NER.

UAV REMOTE SENSING APPLICATIONS- CASE STUDIES AT NESAC

NESAC has taken initiatives in design and assembling of UAV for various applications. Different components of the UAV are selected based on the design parameters and assembled as per the requirements. A hexcopter designed and assembled by NESAC is shown in the Figure 1, which can carry maximum payload up to 2.5 Kg, of different sensors such as thermal, multispectral, optical, hyperspectral or LIDAR. The design parameters of the hex copter are given in the Table 1. A number of flight tests have been carried out to check the capability of the UAV as per design parameters. The flight performance of the hexcopter was tested in terms of payload carrying capability, endurance, flight height and coverage. All test flight results have been found satisfactory considering the proposed flight plans for different applications.

Table 1: Test flight Results of Hex Copter

Sl. No.	Design criterion	Design parameter	Test flight results
1	Payload capacity	Up to 2.5 kg	A maximum of 1.5 kg was tested
2	Flight endurance	Up to 30 min	15 mins for 1.5 kg payload and 25 min for GoPro/YI action camera (weight less than 100 gm)
3	Fly options	Manual, GPS aided, Autonomous	All tested successfully
4	Fly height	Up to 2 Km	Tested up to 500 mt which was good enough for required applications
5	Fly range	Up to 2 Km	Tested up to 1.8 km with clear line of sight

Figure 1: The customizable Hex copter

The Centre is also equipped with a ready-to-fly quad copter (DJI Inspire 1) and a ready to fly hex copter (DJI Matrice 600) as shown in figure 2. The quad copter has a flight endurance up 20 mins with a maximum payload capacity up to 1kg and the hex copter has a flight endurance up to 40 min with a maximum payload capacity up to 4 kg.

In addition, centre is also experimenting in fixed wing UAVs. A V-Tail fixed wing as shown in figure 3 was assembled at NESAC with flight endurance up to 60 minutes, flying height up to 1 km and payload capacity up to 2 kg. The test flights were successful and centre is in process of operationlizing it.

DJI Inspire 1 DJI Matrice 600

Figure 2: Ready to fly quad copter and hex copter at NESAC

The multi rotor based UAV has been flown in different areas of NE states as part of technology developmental activities. Few tests were made based on the demands from the respective District Administrations of NE region. Some of the important case studies made by the centre are highlighted below:

Figure 3: Flight test of fixed wing UAV assembled at NESAC

Mapping of Lum Nehru Park, Umiam:

Mapping of Lum Nehru Park area was taken at the request of Chief Conservator of Forests, Meghalaya Biodiversity Board (MBB), Shillong. The forest department wanted to further develop the existing park in to a butterfly park and required a high resolution map and with contour map of the park area for infrastructure development. NESAC conducted a UAV survey of the park area and submitted data to forest department. The UAV was flown at a height of 90 m and high-resolution map (4 cm) of the park along with a contour map at 50 cm interval as shown in figure 4 was given to the Meghalaya Biodiversity board for further development of the Butterfly Park.

Crop damage assessment due to pest infestation:
Farmers from Morigaon district of Assam reported sudden outbreak of plant brown hopper infestation during the month of April, 2016 in their Boro paddy (summer paddy). At the request of the District Agricultural Officer, Morigaon, UAV survey was conducted in four severely affected villages in the district viz., Naramari, Mikirbheta, Bhurbandha and Jaluguti. The elevation of the UAV was maintained at approximately 120 m. At this height, ground resolution obtained was about 8 cm and the infested areas could clearly be distinguished. Multiple images were obtained with a camera shutter speed of 5 seconds per picture (Figure 5). Figure 6 shows categorization of BPH infested rice fields. Rice plots having more than 60% infestation, categorized as severely affected, less than 60% is categorized as moderately affected. It was found that out of total area of 0.58 sq. km, 0.015 sq. km was severely affected and 0.04 sq. km was moderately affected. It has been mentioned that there will be hardly any output from the crop fields categorized as severely affected; whereas with immediate intervention measures, part of the crop area could be saved.

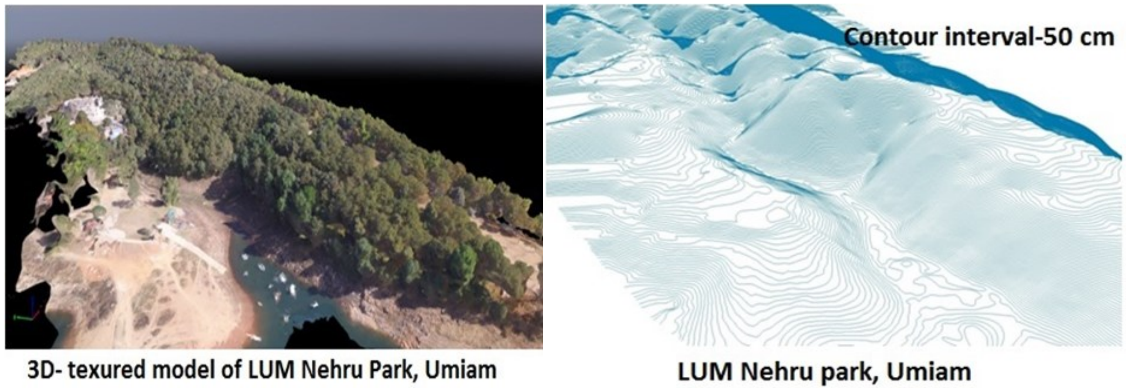

Figure 4: contour map and 3D textured model for Lum Nehru Park, Umiam, Meghalaya

Figure 5: Infested fields in Naramari Village, Morigaon District, Assam

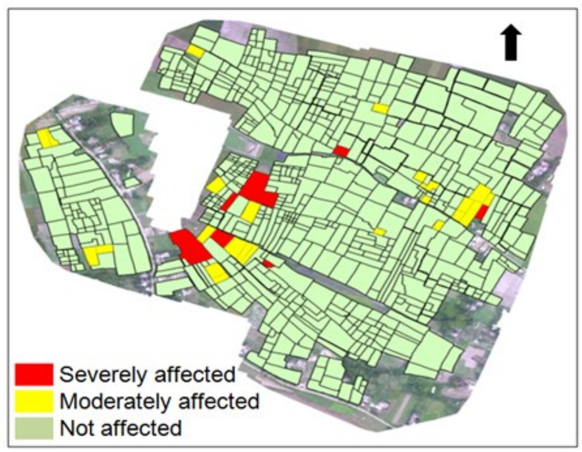

Figure 6: Categorization of BPH infested rice fields

Mapping of Hydropower DAM and power house sites in Meghalaya:
North Eastern Electric Power Corporation Ltd. (NEEPCO) requested NESAC to carry out UAV survey for 2 sites for hydropower project. A high-resolution photography and videography was done for the dam and powerhouse area including the roads nearby from a height of 120 m and the seamless mosaic with 5 cm resolution (Figure 7) along with the full HD video was given to the concern authority for proposed Dam & Power house site location.

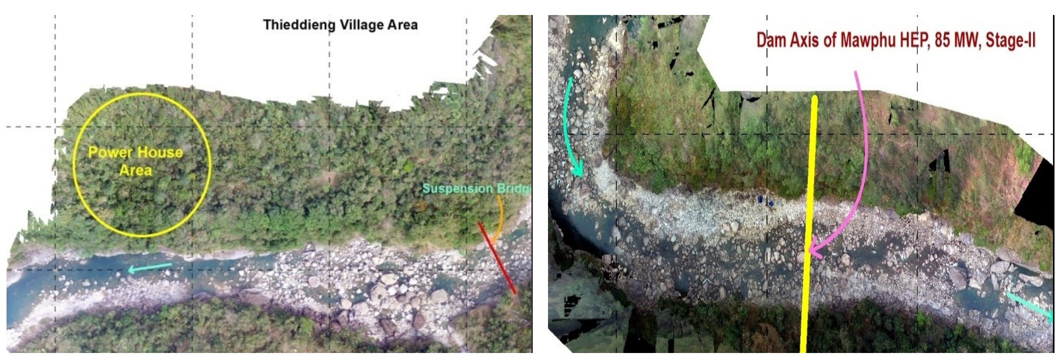

Figure 7: Mapping of proposed DAM and Power house Area for Mawphu phase I & II

Large scale mapping of Nongpoh town of Meghalaya:
Large scale survey was carried out at the request of the Office of the Deputy Commissioner of Ri Bhoi District to support planning activities of Nongpoh Town. Flight was taken at 120 m height along the NH-40 for a

period of 12 minutes with area coverage of 0.84 Sq. Km. The image was acquired with a ground pixel resolution of 5 cm. The land use information extracted from the image of part of Nongpoh town (Figure 8) is presented in the Figure 9. Figure 8 shows the existing land use comprised of about 27 land use classes including the minor single land features of the town. All the land features were precisely identified and mapped in GIS domain. Building structure, road types, lay-overs, open space, even single trees, petrol tanks, etc. could be mapped accurately (Figure 9). This type of information will form the basis for development planning in general and adoption of technical interventions in particular.

Figure 8: Part of Nongpoh Town as viewed from UAV Image, 2016

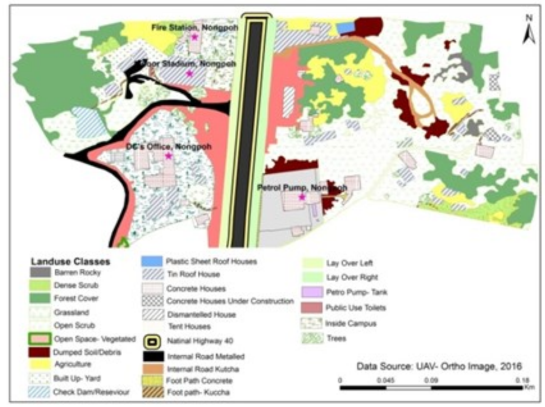

Figure 9: Land Use of part of Nongpoh Town as classified from UAV Image, 2016

APPLICATIONS, OPERATIONAL CHALLENGES AND ISSUES:

UAVs could be the most efficient tools for disaster prone or physically inaccessible areas, quick damage assessment of landslides, floods and earthquakes that will enable relief measures. Its ability to deploy quickly and acquire valuable and accurate information can greatlyenhance the decision making, during disaster situations.

The high resolution spatial products such as ortho photos, elevation model, contours, terrain profile and volume derived from UAV imagery can further improve workflows and decision making process for a variety of applications. In addition, many applications require larger coverage of study to be captured seamlessly. However, it requires UAV to operate in a much higher altitude, which may violate the guidelines of Directorate General of Civil Aviation (DGCA).

Fixed-wing UAVs have limitations in terms of complex designs, difficult stabilizing mechanism, requirement of a long runway and difficult to operate in hilly terrain. However, they have advantages in terms of long endurance and large payload capabilities. On the other hand, multirotor UAVs use vertical takeoff and landing and have been found more appropriate in hilly and complex terrain. However, unlike most fixed wing models of UAVs, the rotary wing models generally have a much shorter flight time.

There are large numbers of demands for UAV data for various applications. However, our applications are still restricted to a limited surveys mainly because– i) limitation in the size of the study area, ii) constraint in processing of large volume of data, iii) requirement of high processing & large storage space etc. In addition, existing features capturing and extraction techniques need to be improved for processing of high dimensional UAV data. The technique of photogrammetry and computer vision has a big role to play for accurate and automatic processing of UAV images. There are also other issues related to the sensor geometrical parameters, atmospheric affects etc. that require to resolve to get accurate UAV imagery.

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Use of Geomatics and Remote Sensing in Dairy Sector with Special Emphasis on Fodder Assessment

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INTRODUCTION

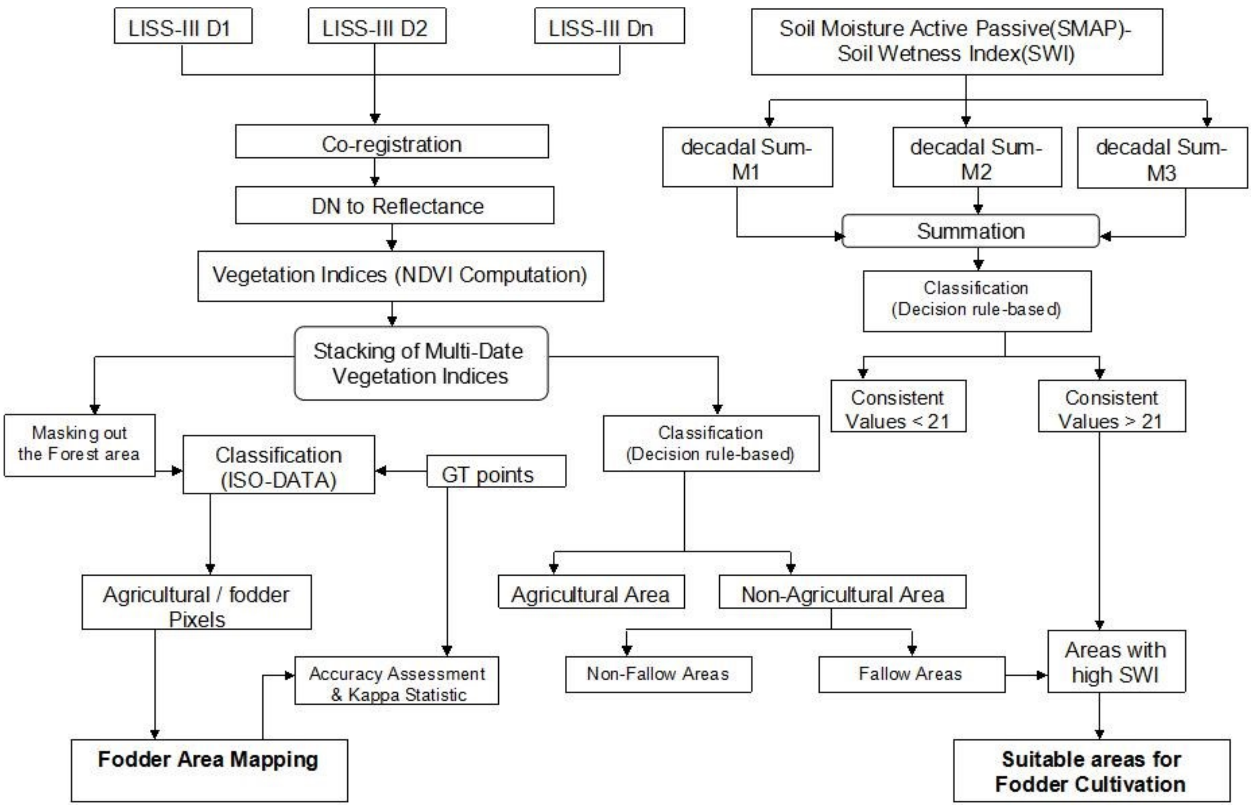
India is the largest producer of milk in the world. The most important aspect of milk production in our country is that it is a major source of livelihood for a large proportion of the rural population, especially small holding farmers. About 80 percent of dairy farmers are marginal, typically owning one to three milk producing animals and contribute about 70 percent to the total milk production. Improving productivity in our dairy sector can potentially contribute to improve food security and stability of national milk prices, in addition to improving the incomes of millions of marginal farmers or milk producers. Due to increasing human population, land available for fodder cultivation has been decreasing. In addition, shift from forage crops to cash/commercial crops like cotton, castor, fruits etc. has led to significant shortage of feed and fodder. This is evident with the sharp increase of fodder prices over the years. One important way in which the productivity can be improved is to improve availability of feed and fodder for the bovine animals. However, less than 5 per cent of the cultivable land is devoted to growing fodder crops.

The development of green fodder mapping is challenging because of the high diversity of agricultural production systems. Generally, farmers are not growing pure fodder crops or they grow in small areas. Further, there is lack of information with government department, regarding the fodder crop growing districts and total green fodder crop areas available in a state. Therefore, efforts are needed by all stake holders in this sector of economy for estimating the fodder areas and to fill up the deficiency gap. There was an urgent need to address this fodder deficit in order to sustain the white revolution brought in by Dr. Kurien. The traditional approach of crop census data is time consuming and biased due to human errors therefore, an alternative approach need to be adopted. With the advent of remote sensing technology in the field of agriculture, it has shown its potential in improving the agricultural statistics in the field of estimation of area under major field crops like wheat, rice, sugarcane, etc. The work on fodder crops through remote sensing have not been extensively reported as compared to major food crops. No specific work based on mapping of fodder crops had been done in India till now. We have tried to implement remote sensing technique for fodder crop assessment at state level to create a base line for developing fodder information system for its management. To address the issue of fodder availability, at first, its assessment is required.

METHODOLOGY

We have tried to assess the green fodder growing areas in one cropping season for states like Gujarat, Rajasthan, UP, Bihar and Haryana. We have devised a technique for remote sensing based fodder crop assessment based on spectral pattern of growth i.e. normalized difference vegetation index (NDVI) profile and Land surface wetness Index (LSWI) profile of series of satellite data taken during the crop growth cycle. Based on these profiles we have tried to segregate between fodder crops v/s other field crops. Since fodder growing areas are far less compared to other food crops, the tendency of misclassification in the form of commission of food crops classes is more. Hereby to avoid that, we have taken a hybrid way of classification. In this approach, we have taken two steps of classification. First step is hierarchical decision rule based classification where all non-agriculture pixels are culled out based on hierarchical decision rule. In this way, major classes of current fallows, forest, wastelands, water bodies get segregated. Then in second step, ISODATA clustering approach is used on rest of the pixels left from first step. Fodder crops pixels are identified based on their spectral profile behaviour and segregated from other food crops. To validate the spectral profile of fodder crops GPS based ground truth observations are recorded as reference curves for spectral profiles of fodder crops. The procedure is shown in flow diagram in figure 1 and the spectral profiles based classification in fig.2.

To address the issue of mitigating the deficit of fodder crops, we have demonstrated the remote sensing technique of identifying the current fallow lands available in a state. We have also generated spatial map of fallow lands available in that cropping season. For macro level planning in a state for developing fodder growing areas, we have demonstrated the availability of soil wetness factor from SMAP data. The intersection of probable high soil wetness area and available current fallows, can be utilized for growing fodder crops. For this approach daily level SMAP data is accumulated and a dekadal (10 day) composite image is created. The consistent available high wetness factor is considered suitable areas for fodder intensification. In India, fallow land available between two cropping season can be utilised for growing short duration fast growing fodder crops. By adopting this technique, satellite derived fallow land can be utilised for mitigating fodder deficit in the country. This technique has been demonstrated at AMUL Inc., Anand and NDDB, Anand.



(D1- Day1, D2-Day2, and D3 -Day3;
M1-1st Month , M2-2nd Month, and M3-3rd Month)

Figure 1: Methodology of Fodder estimation and suitability analysis

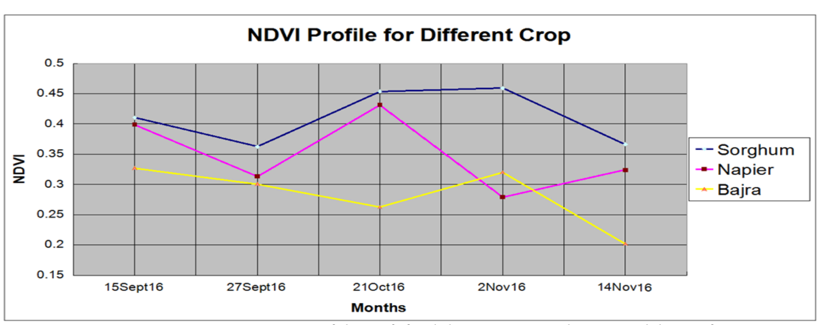


Figure 2: NDVI profile of fodder crops during kharif season

Mobile App based GT

An App. is developed in smart mobile where a simple proforma is to be filled by a farmer or surveyor during Ground Truth (GT) regarding the location of the farm using GPS and other details about crop health, using irrigation, etc. can be filled using smart mobile as shown in figure 3. This can be stored and uploaded to the server using internet in the field visit or which can also be uploaded later from office using internet facility which will be displayed instantly in the server identified beforehand. The server is placed at AMUL center at Anand which is centralized for all milk unions of GCMMF in Gujarat state. Through this App. all surveys can be monitored from one central locations in real time. This has also been used to manage and monitor all agricultural operations centrally for e,g. where to deploy the combine harvester and where the irrigation facility to be augmented, etc. the real time online app. has multi-purpose utility for monitoring the crops through a centrally located place.

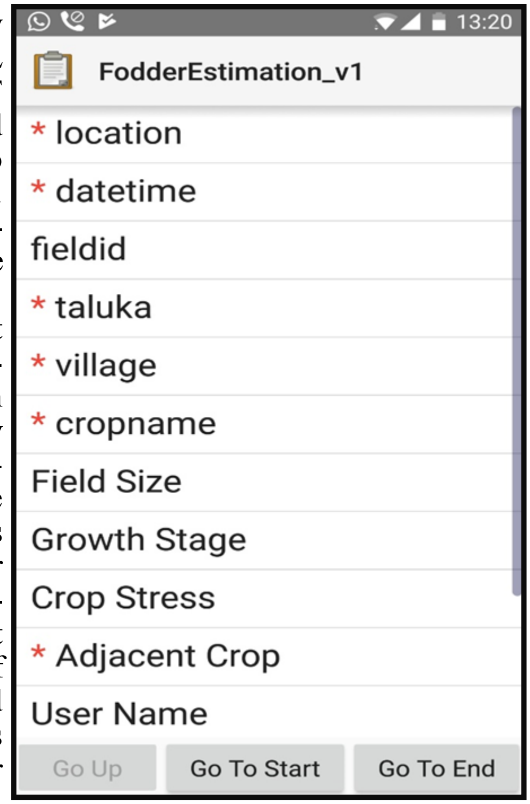


Figure 3: Mobile App. For GT collection installed at Amul Centre, Anand

This app based ground truth can provide real time information about the status of the fodder crops to the manager and he can take decisions regarding any corrective measures need to be taken for farm management. The GPS locations of the farm also gives necessary input regarding where and when the transportation logistics to deployed for effective management of fodder for dairy industry. The App. also provides necessary input to prepare route map for logistics and management of crops. The ground truth collected is also used for remote sensing based fodder crop identification and validation purposes. Field surveys were carried out in different districts of Gujarat State. Ground truth points were collected from various districts of Gujarat. Villages were selected in consultation with Milk Union and the collaborating agency, based on their knowledge about villages growing fodder in significant amount. The field location of fodder growing areas were recorded in term of their geographic position using mobile App. based GPS. Along with this ancillary information such as village name, crop condition, farmer's name, soil moisture, date of sowing and harvesting were collected. From the location details, a point map with attribute information was prepared in GIS, which was used to collect different crop signatures for the spatial assessment of fodder crops in the study area. Since the village level worker collects data at fortnightly or monthly interval. This real time GT data has practical utility for farm management and for diversification of farm resources.

RESULTS & DISCUSSION

The total area under fodder crop in Gujarat district is 285.91 '000 ha. (Figure 5). The Lucerne, and Napier are the important green fodder crops in this state during summer season. Sorghum and Bajra which were also found to be highly cultivated by the cultivators, but it was found to be mainly cultivated for grain purposes rather than fodder. Other crops such as the maize, MP Chari and grass are also used as fodder. The product of these crops is used as a fodder for the livestock. The data given in fig. 4 reveals that Banaskantha (29.7 '000 ha), Sabarkantha (29.3 '000 ha) and Ahmedabad (28.6 '000 ha) are the major fodder growing districts of the state. In Valsad, Dang, Dahod, Panchmahal, Vadodara, Porbandar

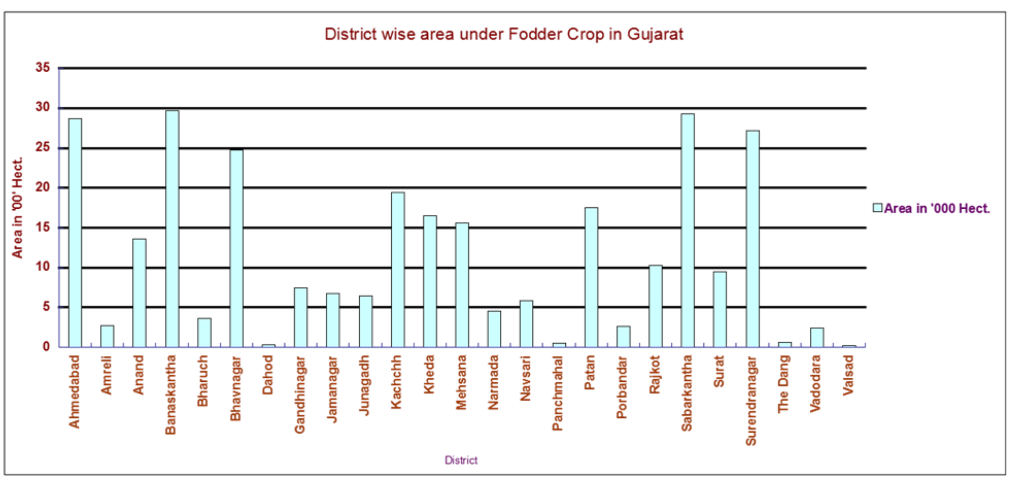


Figure 4: District wise area under Fodder Crops in Gujarat

and other districts, fodder crops areas were found to be very less and scattered when compared to other district of the state as estimated from remote sensing data.

Identification of suitable areas for Fodder cultivation

The multi-temporal NDVI for Gujarat districts were classified using decision based classification and the fallow areas (Figure 6) were identified. The SWI map from September to November first week were used. Each decadal of SWI data were summed and monthly data was generated. This Three monthly generated SWI data was then classified based on decision rule. The pixels which were consistent in the high SWI values (above 21) from September to 1st week November were considered as the high SWI map (figure 7). The intersection of identified fallow areas and soil wetness areas were found out as fallow land with high SWI data to produce the suitable areas for fodder cultivation (Figure 8).

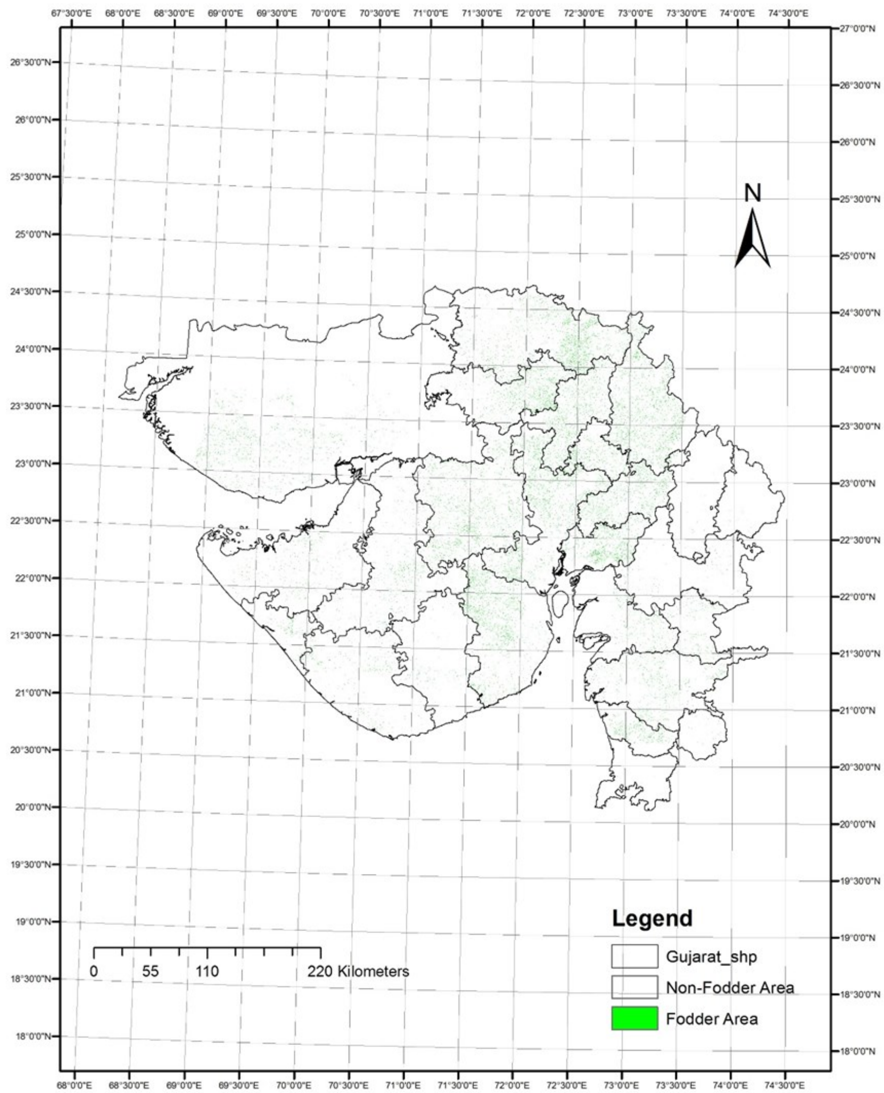


Figure 5: Fodder area of different districts of Gujarat state

Accuracy assessment

The accuracy assessment involves the comparison of a site on a map against reference information (GT) for the same site. Accuracy assessment is essential for comparison between classified imagery and ground truth data to evaluate how well the classification represents the real world. The confusion matrix provided the Overall Accuracy (OA) of the classification, which indicated the percentage of correctly classified pixels; Hundred and two points (102) randomly distributed points on the image were used for calculating the accuracy assessment of the both resulted image classifications shown in table 1. The overall accuracy level was 80.4 percent, the kappa coefficient was found to be 64.4 percent.

CONCLUSION

Multi-temporal NDVI data provided timely information on fodder area in different districts of Gujarat state. North Gujarat comprising of Banskantha, Patan, Gandhinager, Mehasana, Sabarkantha contributed maximum 34 percent of the state area. The central Gujarat comprising of Surendranager, Ahmedabad and Bavnager contributed 29 percent of the state area and South Gujarat contributed 19 percent of the state area. Kachh district alone contributed 7 percent comprising of 194 '000 ha. Estimation of fodder area using remote sensing provided temporal and spatial information on fodder allowing producers to more effectively manage their enterprise and potentially raise the productivity. New and improved methods of remote sensing have tremendously increased the understanding of land surface and its parameters. One of the most significant developments has been the integration of GIS within the study area. The suitable fodder areas were identified by using the SWI data overlayed with fallow areas in the GIS to produce a land suitable for fodder cultivation in the study area. The concept is realized through establishment of a new remote sensing centre at Amul premises in Anand (fig. 9 & 10) which will operationally implement this technique to exploit dairy development further in their respective milk unions. Similarly all 18 milk unions of Amul will gradually implement this in their respective dairies in Gujarat.

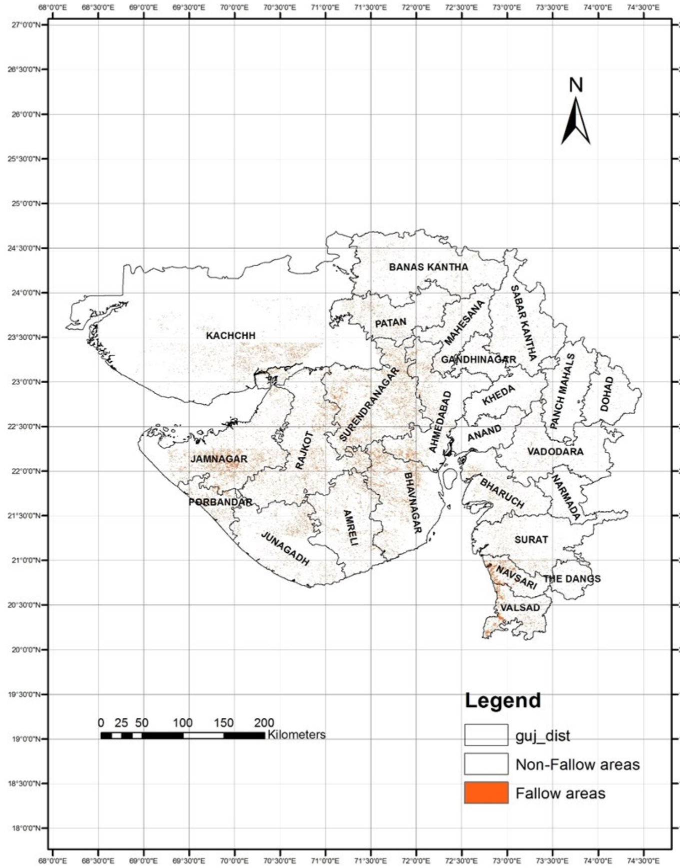


Figure 6: Identified Fallow areas of Gujarat state

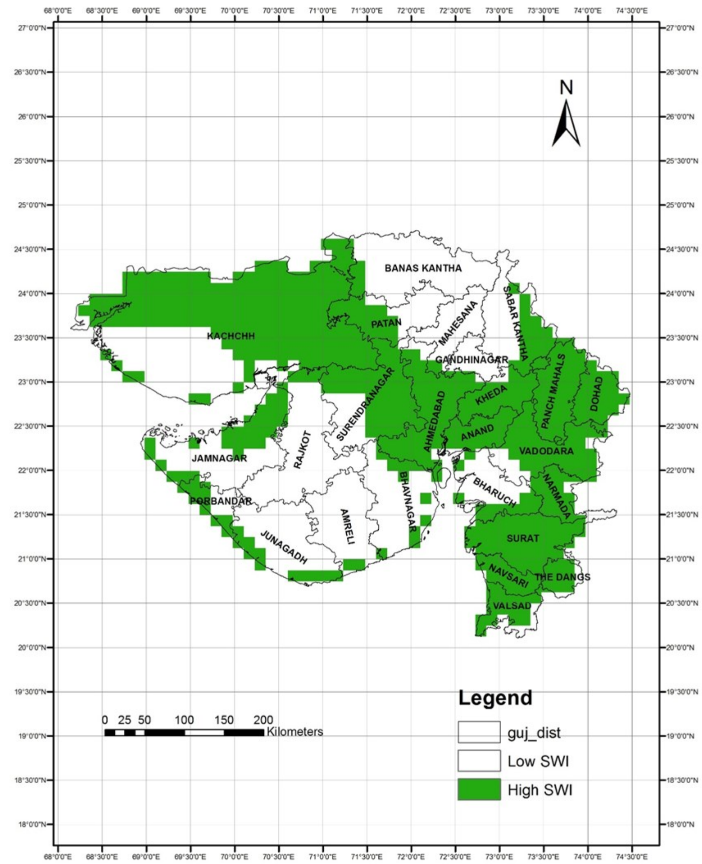


Figure 7: Area showing Soil Wetness Index

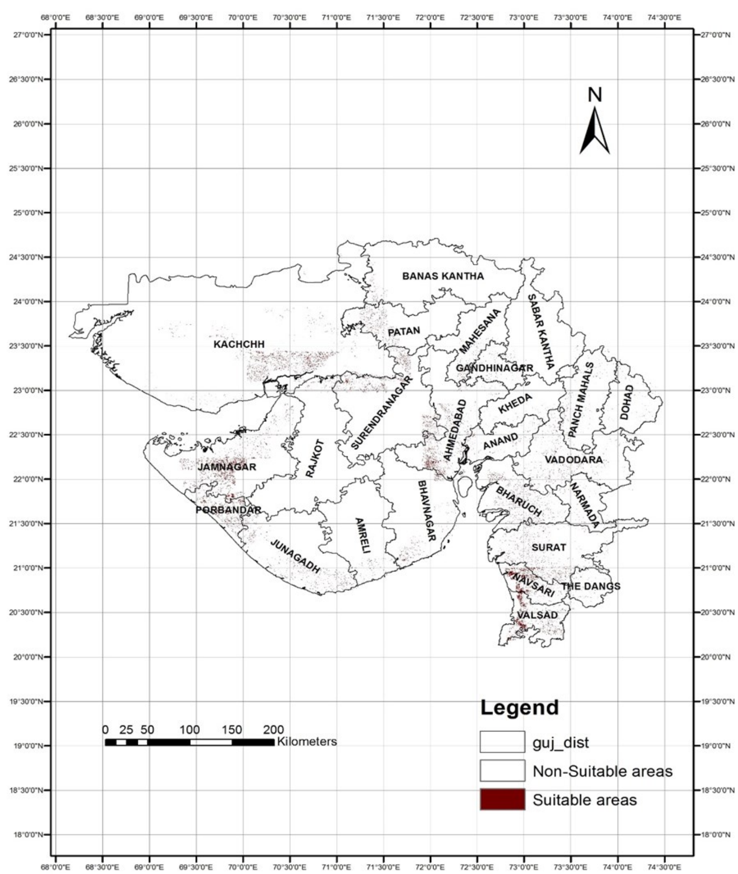


Figure 8: Identified Suitable Fodder areas in Gujarat

Table 1: Contingency table for accuracy assessment

Class	Fod-der	planta-tion	Agricul-ture/ other crops	To-tal	Omis-sion	Com-mission
Fodder	75	7	8	90	15.78	11.11
Plantation	10	15	0	25	40.00	40.00
Agricul-ture/ other crops	0	3	25	28	10.71	28.57
Total	85	25	33	143		
Overall accuracy	115	143	80.42			

Acknowledgements

We are grateful to Shri Tapan Misra, Director SAC, ISRO and Dr. Raj Kumar, Deputy Director, EPSA/SAC for their initiative to carry out this work through TDP budget of SAC program. We are grateful to Shri R. S. Sodhi, M.D., GCMMF, Amul, Anand to encourage this study and giving full support to implement it at all AMUL centers of Gujarat.

Figure 9: Inauguration of Amul Remote Sensing Centre, Anand

Figure 10: Inception of Amul Remote Sensing Centre, at Amul premises, Anand

On the establishment of Corner Reflector network in India and its role in SAR data calibration and quality evaluation

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INTRODUCTION

In view of the availability of SAR data from various spaceborne sensors like ERS-1/2, Envisat, Radarsat-1/2, ALOS PALSAR-1/2, Cosmo Skymed, TerraSAR-X, RISAT-1 and future missions like RISAT-1A and NISAR, it is absolutely necessary to augment the facilities required for the calibration of the data. To compare data from different sensors, extract geophysical parameters from backscatter measurements using models, carrying out multi-temporal studies over large areas, etc., calibrated SAR data products are required. Radiometric accuracy of SAR images is one of the most important factors in order to perform the applications successfully. Calibration and validation is the main activity to verify and maintain the radiometric accuracy and has to be performed periodically.

NEED OF CR NETWORK

The process of radiometric calibration of SAR images involves comparison of the backscattered radar reflectivity signal from a ground resolution element containing a calibration target of known signal response. This process of using ground targets with known scattering properties to derive the radar system transfer function is referred to as external calibration. There are various standard point targets for SAR data calibration which can be classified based on their nature of functionality viz. active and passive standard targets. In active domain, active radar calibrator (ARC) and polarimetric active radar calibrator (PARC) are used whereas in passive domain different types of corner reflectors viz. dihedral corner reflector (DHCR), triangular trihedral corner reflector (TTCR), square trihedral corner reflector (STCR) and luneburg lens are used.
A corner reflector consists of two or three mutually perpendicular electrically conductive surfaces. Incoming electromagnetic waves are backscattered towards the source of the radiation after going through multiple reflections. Figure 1a, 1b and 1c show field photograph of deployed TTCR, STCR and DHCR respectively.

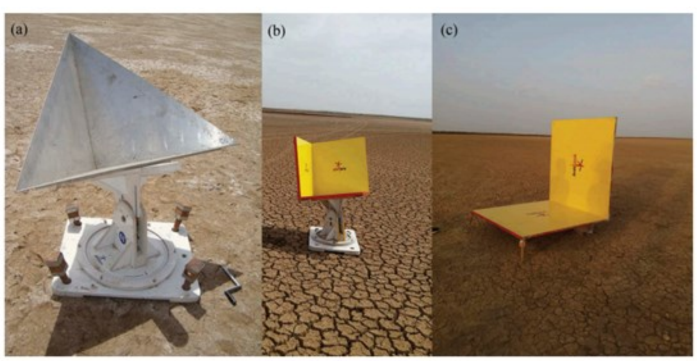


Figure 1(a): Triangular trihedral CR, (b): Square trihedral CR and (c): Dihedral CR

Corner reflectors are considered to be reliable targets for SAR calibration because the magnitude of the returned signal is large relative to the size of the target, the signal response of TTCR is insensitive to errors in alignment (unlike dihedral reflectors), and they are relatively cheap to manufacture and maintain (unlike transponders). If the geodetic location of a deployed CR is accurately known, then it can be used for geometrical calibration of SAR products as long as it is visible above the background signal level in the SAR imagery. Figure 2(a) and (b) show the wave bounce mechanism and bore sight angles respectively corresponding to TTCR.

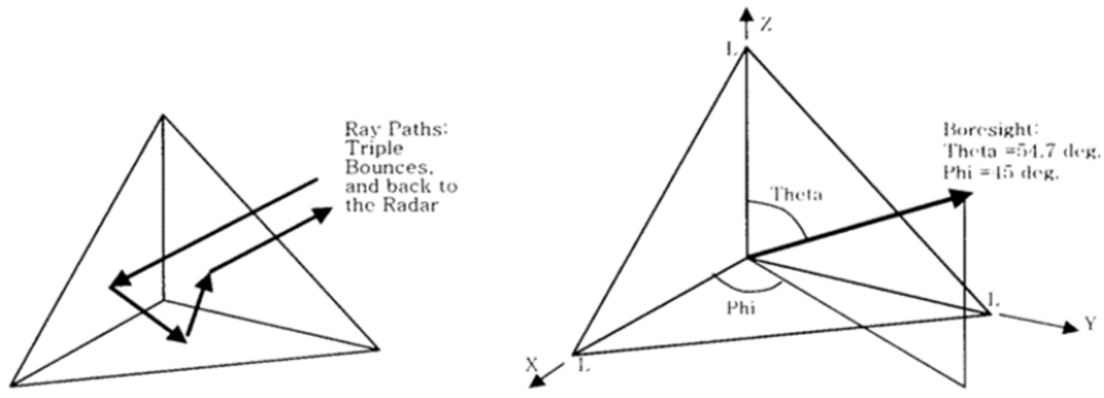


Figure 2: Triangular trihedral CR (a): wave bounce mechanism and (b): bore sight angles

For periodic assessment of the radiometric and geometric calibration and to cover all the beams of future SAR missions, a network of Corner reflector is required. The network will not only help in the calibration study but will also aid the studies related to Interferometric SAR viz. land deformation studies.

Role of CR network in SAR calibration and quality parameters estimation

Calibration and monitoring of SAR instruments parameters with respect to different beams and polarizations is required to ensure the consistency in the derived backscattered values. Use of passive corner reflectors as point targets is one of the fundamental approaches for SAR calibration. To evaluate the image quality parameters, impulse response (IRF) of these reflectors in both elevation and azimuth directions is measured. The SAR response to a point target, assuming negligible background reflectivity and thermal noise, is commonly referred to Impulse Response Function (IRF). The analysis of the signature of a point target in a SAR image allows the determination of several parameters that are related to the SAR side lobe peaks. The image quality parameters that can be evaluated using IRF of CRs are antenna pattern measurement, background to peak ratio (BP) ratio, peak side lobe ratio (PSLR), spatial resolution and integrated side lobe ratio (ISLR). Figure 3 shows the IRF of an isolated point target. The Impulse Response Function is a *sinc* function with a mainlobe and many secondary lobes. The figure shows a one dimensional cut of the IRF in the azimuth direction (spacecraft velocity direction) and two quality parameters measured from it (spatial resolution and PSLR). A SAR image is the result of coherently processing returned echo signals; thus, the pixel values are complex quantities. The peak intensity is the maximum pixel value in the main lobe of the impulse response function.

Spatial resolution

The spatial resolution is the distance between two objects on the ground at which the images of the objects appear distinct and separate. From the impulse response function, it is calculated as the distance between the points with intensities 3dB below the maximum intensity of the main lobe peak in the azimuth and range directions. The definition of the 3dB points is equivalent to the points with half the intensity of the maximum. The ideal spatial resolution of a SAR system can be computed from theory and then compared with that obtained from the IRF analysis. IRF of a point target and the points 3dB below the maximum intensity are shown in Figure 3. The main lobe of the IRF is contained just in one pixel and it becomes impossible to determine the distance between the -3dB points. So, an interpolation is needed by a factor of at least 8 to make the measurement possible.

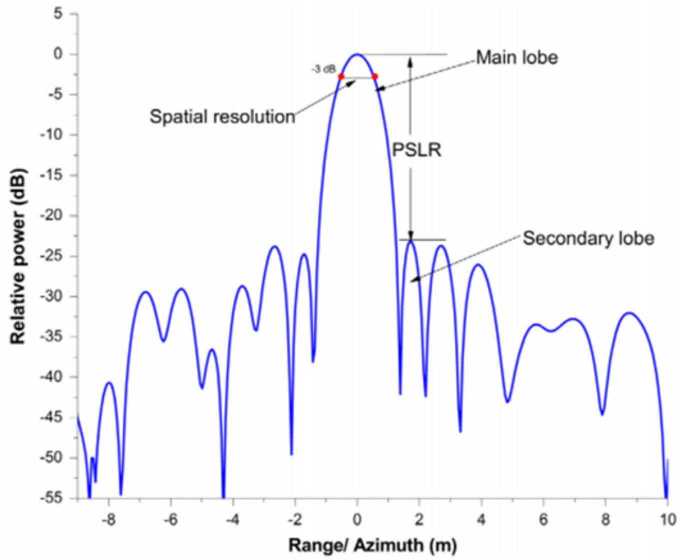


Figure 3: Graphical representation of a SAR point target response showing several quality parameters.

Peak side lobe ratio

The peak side lobe ratio, PSLR, is defined as the ratio of the peak intensity of the most prominent side lobe to the peak intensity of the main lobe. There are two measures of the PSLR, corresponding to the two sides of the main lobe both in azimuth and range directions. This parameter is expressed in decibels. It represents the ability of the SAR to identify a weak target from a nearby strong one.

The PSLR is calculated as

$$PSLR = 10log_{10}\frac{I_s}{I_m} \tag{6}$$

where I_s stands for the peak intensity of the most intense side lobe and I_m stands for the peak intensity of the main lobe. The PSLR may be improved by means of a side lobe clutter and noise minimization with multiple-aperture SAR, which considerably improves the quality of SAR image.

Integrated side lobe ratio

The integrated side lobe ratio (ISLR) is the ratio of the power (energy) in the main lobe to the total power in all the side lobes. It characterizes the ability to detect weak targets in the neighborhood of bright targets and is a measurement of the relative importance of the side lobes with respect to the main lobe.

The European Space Agency (ESA) established the ISLR as the ratio of the power within a square centered on the maximum and ten resolution cells side, without considering an inner window of two resolution cells side and the power in the second window.

$$\mathrm{ISLR} = 10\log_{10}\frac{\int_{10\times10}\mathrm{Idxdy} - \int_{2\times2}\mathrm{Idxdy}}{\int_{2\times2}\mathrm{Idxdy}} \tag{7}$$

Signal to Clutter Ratio

The large RCS is required to ensure adequate visibility above the surrounding background scatterers, often termed clutter. Due to the clutter and noisy environment on the ground, the clutter contribution adjacent to ground-fixed reference target should be taken into account for the performance estimation. One measure of visibility is the target signal-to-clutter ratio (SCR) and is estimated as follows:

$$SCR = \frac{\sigma_P}{\sigma_0 A_{res}} \tag{8}$$

where σp is the backscattered energy of a reference point target and σ0Ares represents the mean backscattered energy of the clutter within a resolution cell. To measure the target signal-to-clutter ratio from an actual SAR image, the ratio of the peak power in the target impulse response to the mean background clutter power, estimated from an area located close to the target, is often used.

Antenna pattern measurement

Accurate removal of the effect of the antenna pattern is necessary for the accuracy of the results of the radiometric calibration. The major errors in the calibration are due to uncertainties in the antenna pattern and in the values of the reference reflectors used as calibration standards. The elevation patterns are generally determined using the responses from uniform distributed targets (bare soil, surfaces, quiet sea surfaces). Amazon rainforest being the largest, most homogeneous, flat area of nearly isotropic scatterers is used as the standard distributed targets.
For determining the antenna pattern using corner reflectors (point targets), they need to be deployed across the whole swath. Then, based on their responses in the image, elevation pattern is estimated. According to the antenna pattern gain, radiometric corrections in range can be performed.

STATE-OF-THE-ART

Globally, two corner reflector arrays are being used for SAR data calibration viz. Rosamond corner reflector array in California and Surat Basin in Queensland. The details of which are as follows:

1. The Rosamond Corner Reflector Array (RCRA) is located near the south beach of Rosamond Dry Lake Bed, California, USA. The array consists of Twenty-three 2.4-meter CRs, Five 4.8-meter CRs and Four 0.7-meter CRs. One of the deployed 2.4 m CR is shown in Figure 4.

Figure 4: Deployed 2.4 m CR in Rosamond

(courtesy: jpl.nasa.gov)

The alignment and construction material of each size of CR is given below:
Alignment
•The 2.4-meter and 4.8-meter CRs are in a 91° line with respect to each other
•The 4.8-meter CRs and 0.7-meter CRs look east with an azimuth heading of 350°
•The 0.7-meter CRs are in a 80° line with respect to each other
•Ten of the 2.4-meter CRs also look east and the remaining thirteen 2.4-meter CRs look west with an azimuth heading of 170°

Construction

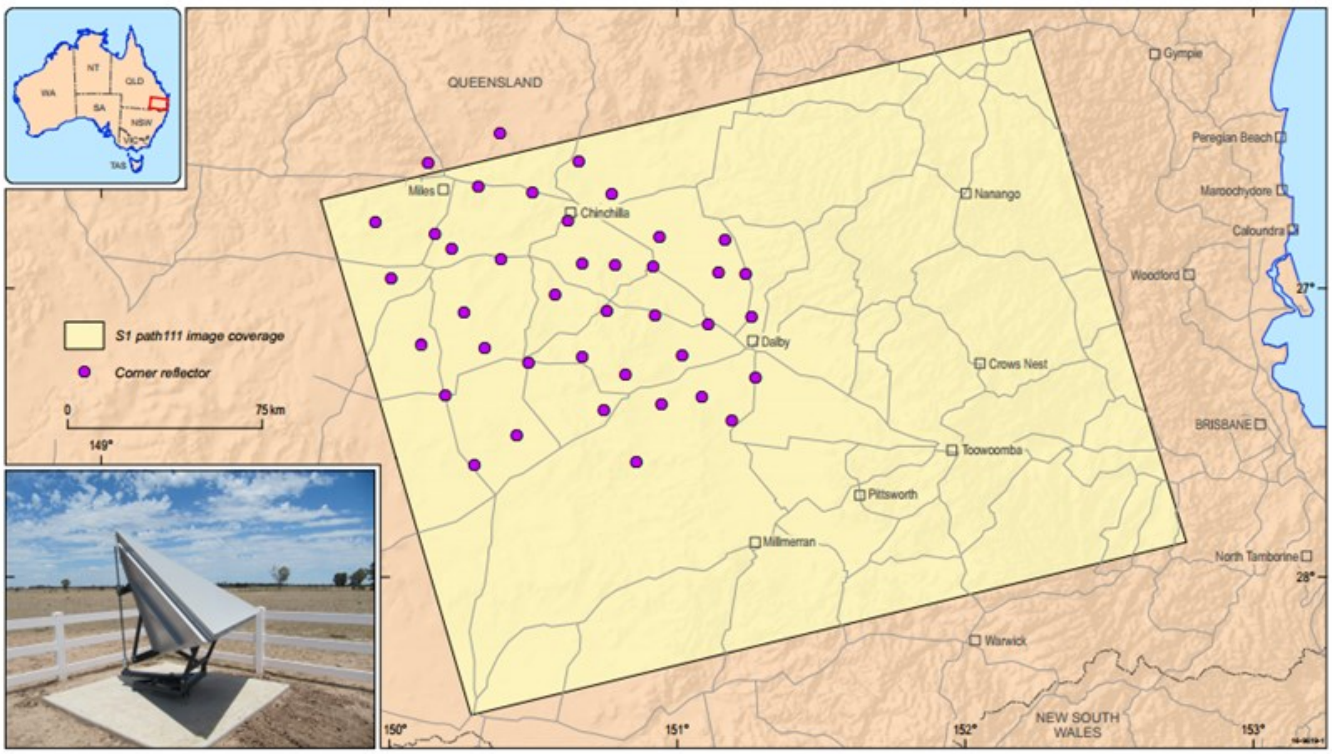
•2.4-meters CRs: constructed with Aluminum Alloy 3003 H14 aluminum perforated sheets with staggered round holes of size 0.09375" (2.4 mm).

•4.8-meters CRs: also constructed with Aluminum Alloy 3003 H14 but with larger 0.5" (12.7mm) round holes, and 48% open surface area. The larger holes in the 4.8-meter CRs allow for lower weight but still compatibility with L-band wavelength.

•0.7-meters CRs: have no holes.

The CRs in Rosamond are well suited for the calibration of L-, P- and Ka band data. The last maintenance of the deployed CRs was done on December 21, 2017 and next is due in May 2018.

2. Surat basin array in Queensland, Australia consists of 40 triangular trihedral CRs covering an area of 20,000 sq Km. This permanent array has been deployed by Geoscience Australia as a part of the Australian Geophysical Observing system (AGOS) initiative to monitor surface deformation. Apart from monitoring crustal deformation, this array is also designed to support calibration and validation of SAR products from orbiting satellites. The array includes 34 CRs of 1.5m, 3 CRs of 2.0m and 3 CRs of 2.5 m inner leg length. The coordinates and details about individual CR sites can be accessed



from the point and distributed targets database maintained by the CEOS WGCV SAR subgroup at http://sarcv.ceos.org/targets/target-group/4/. The map of the Surat basin showing the distribution of the 40 CRs along with the field photograph of one of the deployed CR is shown in Figure 5.

(a) (b)

Figure 6: (a) Field snap of one of the deployed 2m perforated CR at SAC-Bopal site (b) Location of permanent Indian CR network at NRSC-Shadnagar on Bhuvan

For estimating the calibration constant and other image data quality related parameters during commissioning phase and for periodic evaluation of the radiometric and geometric quality of the data, deployment of CR synchronous to satellite pass is required. To cover all the beams and to estimate the near range to far range calibration constants, it is essential to orient the CRs with precise azimuth and elevation angles, which if done in a campaign based mode require much efforts and manpower hours. Also, one difficulty of CR deployment campaign is finding enough secure sites where reflectors can be left in place. They cannot be placed on rooftops as the surrounding clutter will affect their visibility. On the other hand, constantly deploying and then dismantling the reflector for each pass may compromise the accuracy of its position and also can damage the CRs which will further affect the accuracy of the radiometric calibration results.

Because of the aforementioned problems of campaign mode deployment. Permanent network of CR is needed. It will reduce the human efforts and will also lead to better accuracy of the results. In this regard, an initiative has been made by SAC-ISRO to establish a pan India CR network for SAR calibration. For the proper calibration of the data, suitable site selection for the point target deployment is the prime requirement. For permanent CR deployment, suitable sites are required and it is decided to establish at least one site in each Indian state. For the selection of the site, educational institutes viz. IITs, NITs, Universities and regional remote sensing centres RRSCs were selected. In the first phase,

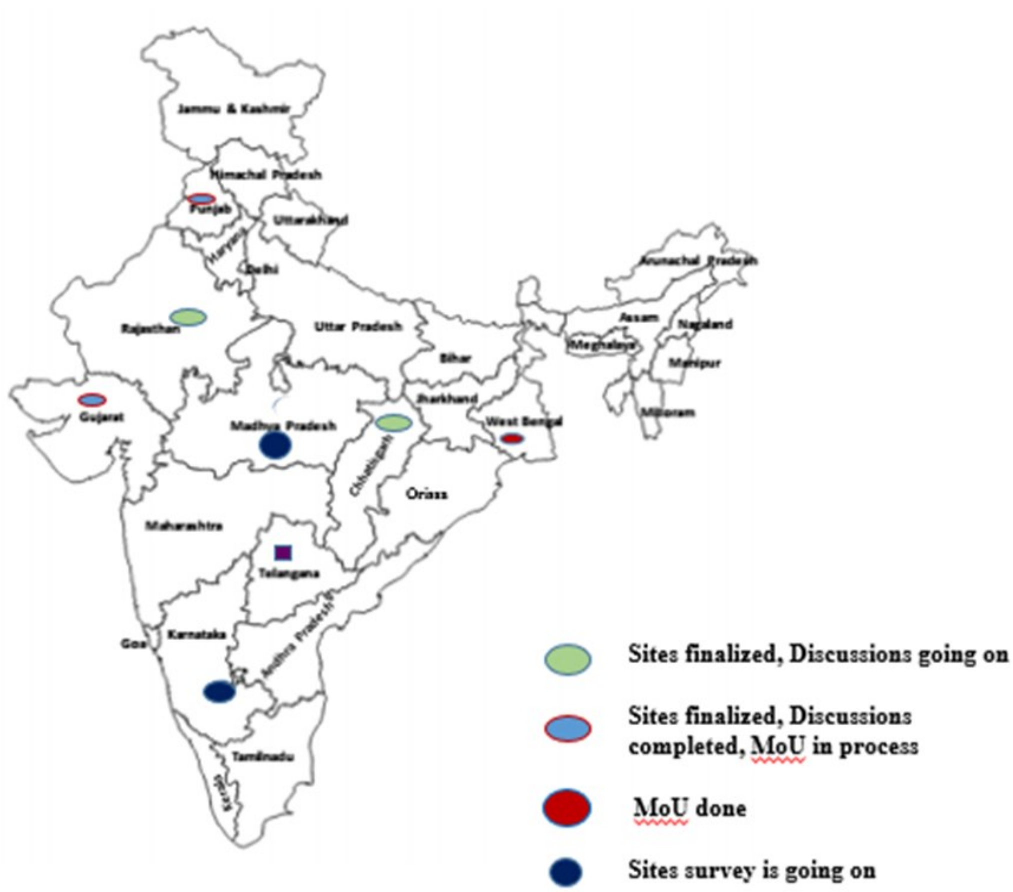


Figure7: Current status of pan India permanent CR network

five Indian states Gujarat, Rajasthan, Punjab, West Bengal and Chhattisgarh were finalized. Based on the discussions with the concerned authorities at the University/IIT/NIT/RRSC in these states and after doing survey at their campus, suitable area was selected for CR deployment. Electric pole, high tension wires, buildings, metal fencing and crowded places were avoided while selecting the sites. The requirement of levelling and flattening of the selected sites was also requested in these areas.

At present, one MoU has been done with IIT Kharagpur in Eastern India and few CRs have been installed which at present are being tested and SAR data over these CRs is being analysed.

In the Western India and Northern India, sites have been finalized in Gujarat and Punjab respectively, discussions completed and formalities related to MoU is under process. Figure 7 shows the pan India permanent CR network status.

With the upcoming SAR misiions having large swath such as mission like NISAR which is having 250 Km swath, finding out large, flat and homogeneous low background site free from man-made structures for CR deployment is a challenging task. In this regard, it is also planned to set up a CR network at Antarctica too as it is a potential site for calibration as it fulfils many of the criteria required for the ideal calibration site. At present only few countries (US, Italy-France and Germany) have deployed CRs at different parts in Antarctica for various studies like mass-balance, InSAR and for localization accuracy related studies. This network will not only help in the calibration study but will also aid the studies related to InSAR i.e. land deformation studies.

CONCLUSIONS

With the increase of SAR missions, augmentation of the facilities for the calibration of SAR data is very much required. Currently, only two permanent CR arrays are there globally which are being used for calibration activities. Also, to cater to the need of large swath missions, it is very much required to have a permanent CR setup. It will not only reduce human hours' loss, efforts but it will also help in increasing the reliability of the calibration results. The initiative taken by SAC-ISRO to establish a permanent CR network pan India is one of its kind and once operationalized it will be very helpful in calibration and validation studies.

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Calculator for Solar Energy Potential Using Satellite Data

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Introduction

Solar energy is one of the most sustainable form of renewable energy, both environmentally as well as economically, particularly so for developing countries. India, which has a cumulative installed capacity of 8 GW of grid-connected solar power, has set an ambitious target of attaining 100 GW of solar capacity by 2022. This includes 40 GW of grid-connected roof-top solar installations. The energy demand is increasing day by day due to increased pressure of population and urbanization. With approximate 300 clear sunny days a year, India has approximate 5000 trillion kWh/m^2 incident solar energy, which is more than the possible energy output of all fossil fuel energy reserves in India.

The solar energy is clean, pollution-free and abundant in nature. Its frequency in availability is also very high. The use of solar water heaters, solar photovoltaics, solar power plants are some of the ways to adopt solar energy in our lives. Furthermore, the buildings may also be designed in such a way that they can consume and utilize solar energy to meet its energy requirements. Solar energy is one of the prominent renewable energy in these building, mainly in tropical and sub-tropical regions. Photovoltaics (PV) or Solar cells convert sunlight directly into electricity. PV systems can be integrated in the building skin, i.e. roofs and facades. The electricity generated by the PV systems installed on the rooftops of residential, commercial, institutional and industrial buildings can be fed into power grid at regulated feed-in tariffs (referred as Grid-connected Rooftop Solar Installation), or can be used by building for self-consumption.

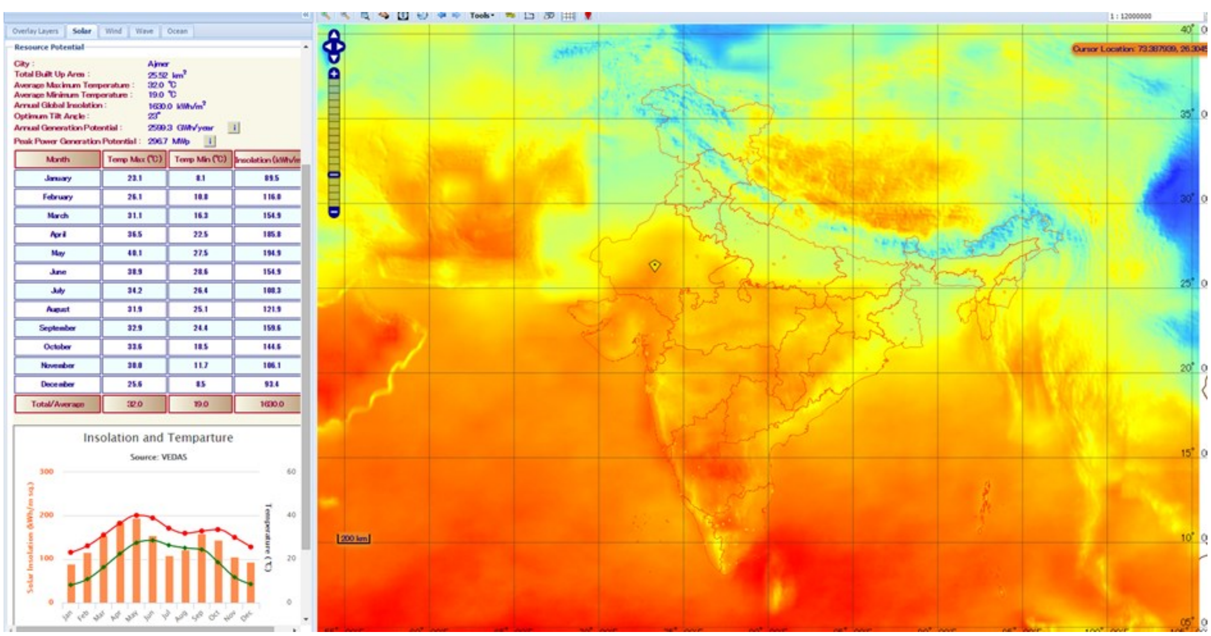
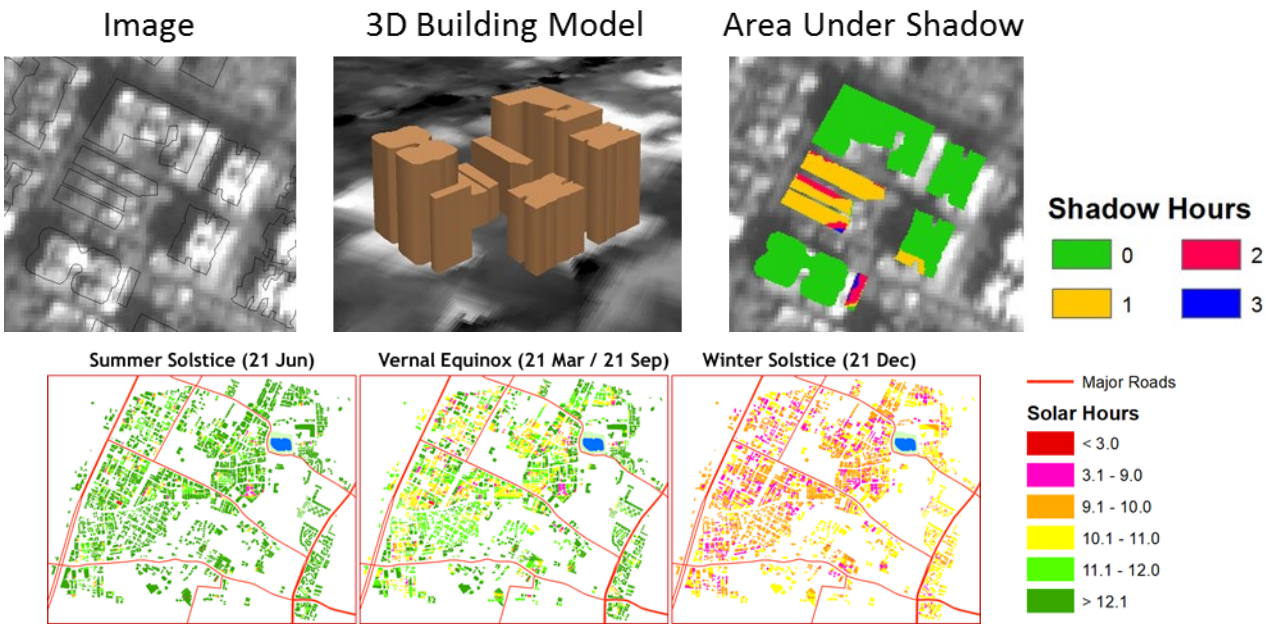


Figure 1 : Solar Insolation Map for India using Kalpana & INSAT satellite data

The power output of a photovoltaic cell is directly proportional to incident solar irradiation on the cell. The higher the solar irradiation, the higher the power output of a photovoltaic cell. The global (total) horizontal insolation (GHI), combining direct as well diffuse component of incident solar energy, is obtained from the half-hourly observations at 8 km spatial resolution in optical and thermal infrared bands form the Indian geostationary satellite KALPANA-1 Very High Resolution Radiometer (VHRR) and at 4.0 km spatial resolution from INSAT 3D. The data is available on MOSDAC (www.mosdac.gov.in) web portal of ISRO. The detailed methodology of retrieving GHI along with validation results, which includes spectrally integrated clear-sky and three-layer cloudy-sky models to determine the atmospheric transmittances and instantaneous surface insolation, is developed by Bhattacharya. The VEDAS web-portal (https://vedas.sac.gov.in), developed by Space Applications Centre (SAC), Ahmedabad, provides information on monthly and yearly potential solar along with monthly minimum and maximum temperature, annual sun path, daily solar hours and forecast for next 72 hours. Figure 1 shows average annual insolation over India.



	Jun 2016	*Mar 2016*	*Dec 2016*
Total Solar Hours	*13h 24m*	*12h*	*10h 34m*
% Area Under Shadow for More than two Hours	*10.0%*	*8.0%*	*6.0%*
% Shadow Free Roof Area Between 09-16 Hrs	*98.87%*	*98.25%*	*96.01%*

Figure 2: Shadow analysis using 3D City building model

Urban areas are typically characterized by the presence of multiple non-lambertian reflection effects of local environment, variability of slope, complexity of shadow effects in relation to complexity of urban geometry. This requires modelling of incident radiation on a tilted plane with complex shadow effects on diffuse and direct component. The surface solar irradiance in urban areas needs to account for the shadow effects, sky obstruction, reflection and terrain-atmosphere coupling. The 3D city buildings models created using Cartosat-1 PAN stereo-pair can be used to model the effect of shadow on building roof tops and to determine the roof area suitable for installation of solar panels. Figure 3 shows the 3D building model of few buildings in Ahmedabad city and corresponding length of shadow (in hours) on their rooftops for a given day. The length of shadow aggregated over entire year provide buildings suitable for installation of solar panels as well as portion of building where such panels can be placed so as to minimize the effect of shadow.

Android App for Solar calculator

An android app has also been developed for computation of solar energy potential at mobile user's location. Solar insolation is obtained using Indian Geostationary satellite data. It is a very useful tool for installation of PV Solar panels for tapping solar energy. It provides monthly / yearly solar potential (kWh/m^2) and min/max temperature at any location. It also displays location on image and provides azimuth / elevations angles as well as day length over different time periods in a year. Obstruction of sunlight due to terrain is also computed using DEM. This app can be downloaded from ***https://vedas.sac.gov.in*** (Figure 3)**.** A 72 hour forecast and usage of app is shown in figure 4. Till May 2018, more than 11000 people have used this app to find solar potential.

Map representation

Graphical representation

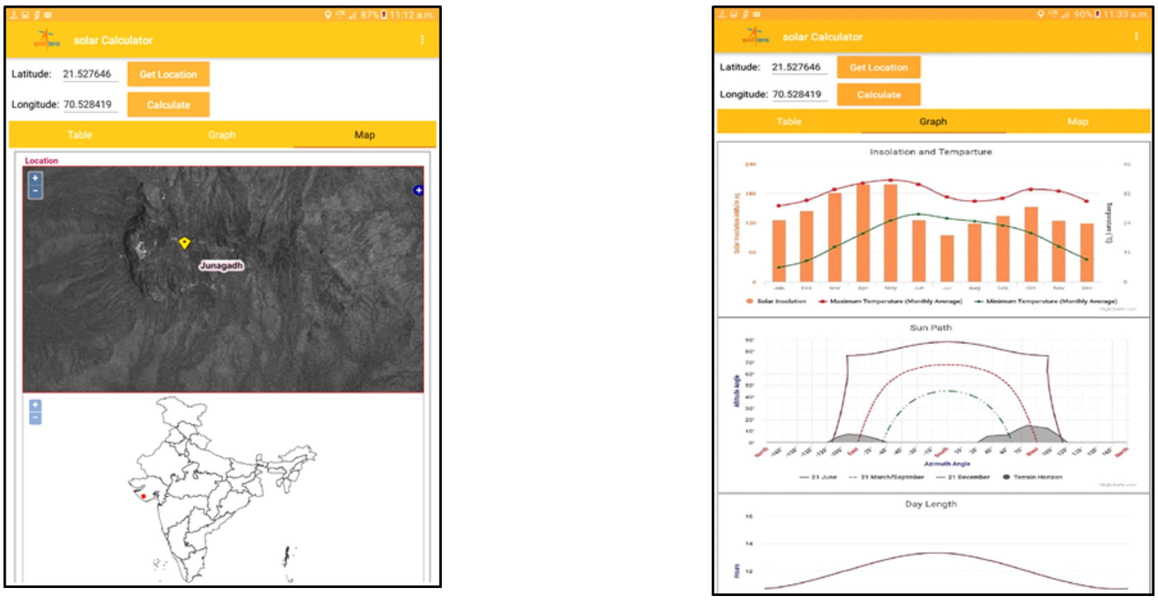


Figure 3: Solar Calculator Android App

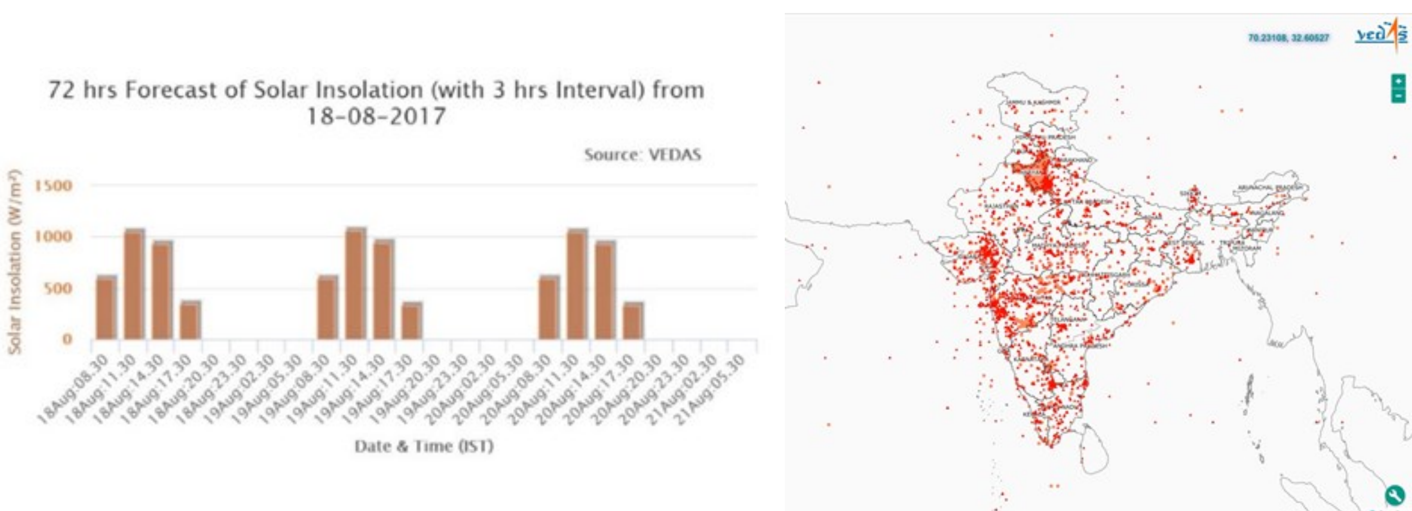


Figure 4. Insolation forecast and Solar Calculator App usage distribution as till May 2018

Three decades of IRS applications in India

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Exploring the satellite remote sensing for Earth Observation started way back in 1960s with the launch of TIROS-1 spacecraft. Since then, there has been tremendous progress in developing earth observation platforms with a wide variety of remote sensing instruments. They scope of remote sensing applications has enhanced with the progress made in data processing and data interpretation techniques. Launching of two experimental earth observation satellites, Bhaskara I and II in 1979 and 1981 carrying both optical and microwave payloads provided the initial thrust to learning process. In early 80's a series of experimental satellites like RS-D1 and RS-D2 were also launched. Indian space programme since its inception has been oriented towards providing solution to actual problems in the country. Realizing the significance of orbital remote sensing, country initiated, evolved and developed its own space programme for earth observations.

Identification of coconut trees affected by the root-wilt disease on the colour infrared images obtained from a helicopter in 1970 heralded remote sensing in its present sense in India. This pilot project led the development of Indian Remote Sensing (IRS) satellites.

ISRO is continually engaging all stake holders for improvement of earth observation systems and applications. Regular interactions, with user departments, researchers and academia right from the beginning, lead to evolving observation needs based on demand and gap analysis. This lead to steering of the Indian Space programme so as cater all domains of land, ocean and atmosphere. ISRO, keeping the momentum and pace with global earth observation developments, periodically augmented the technological capability encompassing space, ground and the applications segments and required resources to meet the ever increasing demands. ISRO's sophisticated technological capabilities and its growing regional and global influence has made the country proud. ISRO has made remarkable progress towards building the space infrastructure as the *Community Resource* to accelerate various developmental processes and harness the benefits of space applications for socio-economic development. ISRO has established two major operational systems– the Indian National Satellite (INSAT) for telecommunication, television broadcasting, and meteorological services and the Indian Remote Sensing Satellite (IRS) for monitoring and management of natural resources and Disaster Management Support. The IRS satellites observe the planet Earth from space and provide us periodically synoptic and systematic information pertaining to land, ocean and atmosphere and several aspects of environment. The information so generated is a key input in the programmes of the government at the Centre and State towards monitoring and management of natural resources, developmental activities and for better governance.

The space inputs for remote sensing of land/crops are multi resolutions, multispectral bands and high repetivity, time series, long-term observations while atmospheric observations need cloud motion vectors, rain rate, vertical profiles of temperature and humidity. The ocean measurements of ocean colour, sea surface temperature, wave height etc are needed for fishery prospects. The communication and navigation technologies has improved the outreach/broadcasting, data dissemination, geolocation etc. Geographic Information System has helped in geospatial techniques exploration for information derivation. During the last three decades varieties of instruments have been flown onboard the IRS satellites to provide necessary data in a diversified spatial, spectral and temporal resolutions to cater to different user requirements in the country and for global usage (table 1).

An era of operational remote sensing programme started in India, three decades ago with the launch of IRS-1Aon March 17, 1988, which was followed by IRS-1B and P2 in 1991 and 1994, respectively. Indian earth observation systems programme was applications driven and user oriented. With many field based studies and accuracy improvement campaigns, a need was felt to have further improvement in spatial and spectral resolutions. The IRS 1C/1D missions were planned with panchromatic camera, LISS-III camera and a Wide Field sensor (WiFS) which incorporated enhanced capabilities in terms of spatial resolution, spectral bands, stereoscopic imaging, Wide Field Coverage and revisit capability, and also the SWIR band.

The three tier cameras viz., LISS-IV, LISS-III and Advanced Wide Field Sensor (AWiFS) on boardResourcesat-1(IRS-P6, Oct,2003) and Resourcesat-2/2A (Apr, 2011, Dec, 2016) was very unique to remote sensing applications as they catered to multiple levels of applications. IMS-1 (2008) carrying four bands in VNIR and Hyperspectral Imager was also launched. These were extremely useful for land and natural resources. These added to higher temporal resolution apart from data continuity. The above satellites were used for variety of applications such as agriculture, snow cover mapping, coastal zones studies, ground water prospects, natural resources mapping etc.

The imaging RADAR has supplementary and complimentary information to its counterpart in the optical region. India being agrarian country, the main season, viz., kharif season needs data assurance for operational applications. The all-weather capability, day/night imaging challenge was met when India conceived and accomplished C-band SAR sensor flown on RISAT-1 satellite (April, 2012). This was an important milestone for ISRO. The RISAT-1 data was used for crop monitoring, especially during the Kharif season, flood monitoring, disaster management applications and many R&D studies.

Cartosat-1 (May, 2005), Cartosat-2 (Jan, 2007), Cartosat-2A/2B (Apr, 2008, July, 2012) and Cartosat-2S were aimed at providing high resolution data to cater to cartographic and terrain mapping needs. Along-track stereo data was acquired using Cartosat-1 which was used to generate digital elevation at 10 m posting, the Cartosat-2, 2A and 2B were aimed at improving cadastral mapping. TES (2001) had submeter imaging capability. Cartosat 2S-1/2S-2 had 0.65m PAN and 2 m multispectral camera.

India has coastline of about 7,500 km and fisheries is an important sector. Modular Opto-electronic Scanner (MOS) sensor on board IRS-P3 (March 1996) was useful for ocean colour studies. IRS-P4, Oceansat-1 (May, 1999) was the first Indian satellite, with Ocean Colour Monitor (OCM) and Multi - frequency Scanning Microwave Radiometer (MSMR), for ocean applications. It was useful for chlorophyll, coastal dynamics, sea surface temperature, atmospheric water content over oceans etc. Oceansat-2 (2009) had modified OCM, Ku band Scatterometer for ocean wind vector measurements and a Radio Occultation Sounder for Atmosphere (ROSA) for profile measurements of humidity and temperature. SCATSAT-1 (September, 2016) was continuity to Oceansat-2 Scatterometer. Its wind vector data products are useful for weather forecasting, cyclone detection and tracking services.

The joint ISRO-CNES mission Megha Tropiques (Oct, 2011) and SARAL (Satellite for ARGOS and ALTIKA) (Feb, 2013) were aimed at understanding water cycle and energy exchanges in the tropics. The payloads, microwave radiometer (MADRAS), a multi-channel microwave humidity sounder (SAPHIR) and a radiation budget instrument (SCARAB) were part of Megha Tropiques mission. The SARAL with Ka-band Altimeter and ARGOS data collection system payloads was intended for ocean surface topography applications.

Many EO applications such as agriculture, forestry, disasters etc rely on weather and climate. Over the years IRS data and weather information are used conjunctively for analysis, assessment and forewarning. Now casting & Short-range Prediction for heavy rain fall events have been developed. Clear-Sky radiances for assimilation in global weather prediction model using INSAT-3D/3DR was developed and implemented at NCMRWF for improved weather prediction. About 32 geophysical parameters are operationally generated from INSAT-3DR. High resolution urban surface temperature monitoring and prediction is estimated using INSAT-3D/3DR.Tropical cyclones are among a few weather systems that have high societal and economic impact. India's vast coastline is highly vulnerable to cyclone hazard. Some of the world's deadliest cyclones have occurred over the India-Bangladesh coastline. Satellite observations have helped a great deal in mitigating the human loss of life related to cyclone during recent decades. Observations at visible and infrared channels from INSAT satellite provide routine observations of tropical cyclones with high temporal sampling. This helps to track the position, movements and intensity of cyclones at frequent intervals, which are crucial for disaster preparedness and disaster management. Microwave observations like surface winds from OCEANSAT-2 Scatterometer (OSCAT) are now operationally being utilized to identify the signatures of cyclogenesis. The patterns of wind circulation in OSCAT observations can be used to identify the genesis of a cyclone almost four days in advance. This kind of prediction provides a very early warning of cyclone development that helps forecasters, planners and disaster management agencies to gear up for an impending natural hazard. These predictions of cyclogenesis are routinely made available at ISRO's MOSDAC web portal.

Satellites (year)	Sensor	Spectral Bands (µm)	Spatial res (m)	Swath (km)	Radiometric res. (bits)	Repeat cycle (days)
IRS-1A/1B (1988,1991)	LISS I	0.45-0.52 (B) 0.52-0.59 (G) 0.62-0.68 (R) 0.77-0.86 (NIR)	72.50	148	7	22
	LISS- II	Same as LISS-I	36.25	74	7	22
IRS-P2 (1994)	LISS – II	Same as LISS-I	36.25	74	7	24
IRS -1C/1D (1995-1997)	LISS –III	0.52-0.59 (G) 0.62-0.68 (R) 0.77-0.86 (NIR) 1.55-1.70 (SWIR)	23.5 70.5(SWIR)	141 148	7	 24
	WiFS	0.62-0.68(R) 0.77-0.86 (NIR)	188	810	7	24(5)
	PAN	0.50-0.75	5.8	70	6	24(5)
IRS-P3 (1996)	MOS-A	0.755-0.768 (4 bands)	1570 x 1400	195	16	24
	MOS-B	0.408-1.010 (13 bands)	520 x 520	200	16	24
	MOS-C	1.6 (1 bands)	520 x 640	192	16	24
	WiFS	0.62-.0.68 (R) 0.77-0.86 (NIR) 1.55-1.70 (SWIR)	188	810	7	5
IRS-P4 / (OCEANSAT-1) (1999)	OCM	0.402-0.885 (8 bands)	360 x 236	1420	12	2
	MSMR	6.6, 10.65, 18, 21 GHz (V & H)	150, 75,50 and 50 km respectively	1360	-	2
	CCD	Vis, NIR, SWIR	1.0 km			
IRS-P6 / RESOURCESAT-1 (2003)	LISS – III	0.52 –1.701 (4 bands)	23.5	141	7	24
	AWiFS	Same as LISS-III	56	737	10	24 (5)
	LISS- IV	0.52 -0.59 (G) 0.62 – 0.68 (R) 0.77 – 0.86 (NIR)	5.8	70	10(7)	24 (5)
CARTOSAT-1 (2005)	PAN (Fore (-26°) & Aft (-5°)	0.50 - 0.85	2.5	30	10	5
CARTOSAT-2 (2007)	PAN	0.50 – 0.85	0.8	9.6	10	5
TES (2001)	PAN	0.50 - 0.85	1	13	7	5
CARTOSAT-2A (2008)	PAN	0.50 – 0.85	1	9.6	10	310 (4)
IMS-1 (2008)	MX	Same as LISS-I	36.87	636.18	10	25
	HySI	400-950 (64 bands)	505.6	129.5	16	
RISAT-2 (2009)	X- Band	9.0 GHz	3-8	10-50	-	-

Satellites (year)	Sensor	Spectral Bands (µm)	Spatial res (m)	Swath (km)	Radiometric res. (bits)	Repeat cycle (days)
OCEANSAT-2 (2009)	OCM	402-885 (8 bands)	360 x 252	1420	12	2
	SCAT	13.51 GHz	50	1400	12 hrs	
	ROSA	1560-1590 MHz 1212 -1242 MHz				
CARTOSAT-2B (2010)	PAN	0.50-0.85	1	9.6	10	310 (4)
RESOURCESAT -2 (2011)	LISS – IV	0.52-0.86 (3 bands)	5.8	70	10	24
	LISS- III	0.52-1.70 (4 bands)	23.5	141	10 (VNIR) 7 (SWIR)	5
	AWiFS	0.52-1.70(4 bands)	56 (nadir) 70 (off-nadir)	740	12	5
MEGHA TROPIQUES (2011)	MADRAS	18.7, 23.8, 36.5, 89.0, 157 GHz	1700	40, 40, 40, 10, 6		3-8 times a day
	SAPHIR	183.31±0.2, 1.1, 2.8, 4.2, 6.8, 11 GHz	1705	12		
	ScaRaB	0.5-0.7 0.2 -4.0 02-200 10.5-12.5	2242	40		
	ROSA	1560-1590 MHz 1212-1242 MHz				
RISAT-1 (2012)	C- Band	5.35 GHz	3-50	25-225		25
SARAL (2013)	Ka-band	35.75 GHz		8		35
RESOURCESAT-2A (2016)	LISS – IV	0.52-0.86 (3 bands)	5.8	70	10	24
	LISS- III	0.52-1.70 (4 bands)	23.5	141	10 (VNIR) 7 (SWIR)	5
	AWiFS	0.52-1.70(4 bands)	56 (nadir) 70 (off-nadir)	740	12	5
CARTOSAT-2S (1) (2016)	PAN	0.45-0.90	0.65	9.6	11	310 (4)
	MX	Same as LISS-I	2.0	9.6	11	
SCATSAT-1	Scat	13.51 GHz	50	1400	12 hrs	
CARTOSAT-2S (2) (2017)	PAN	0.45-0.90	0.65	9.6	11	310 (4)
	MX	Same as LISS-I	2.0	9.6	11	
CARTOSAT-2S(2)(2018)	PAN	0.45-0.90	0.65	9.6	11	310 (4)
	MX	Same as LISS-I	2.0	9.6	11	

Evolution and accomplishments of Earth observation applications

The beginning of Indian Earth Observation programme had studies based on aerial photography in the 70s followed by many studies using aerial and Landsat data. The experimental campaigns such as Agricultural Resources Inventory Experiment (ARISE in 1974-76), Landuse studies of Idduki, Mandya Crop Inventory Experiment, Integrated Resources Survey of Panchamahals of Gujarat and Joint Experiments Programme did set the pace for defining the operational programmes using remote sensing. During the last three-decade, earth observation applications have evolved and matured in various domains. The Indian Remote Sensing (IRS) satellites have been the workhorse for several applications - encompassing the various sectors. Some of them are in the area of landuse/landcover, wastelands, land degradation, watershed development, agriculture, agro-meteorology, forestry, biodiversity and wetlands, hydrology, geological and mineral resources, cartography, urban planning and infrastructure development, marine and coastal applications, natural resources mapping, disaster management support, and global changes. This further enhanced the user involvement and demanded the value added products and services, that too with short turnaround time or near real time.

During the past three decades, space technology inputs is recognised as an important input in governance and development and for natural resources management. It aids in informed decision making.

In the field of agriculture, the techniques have been developed for operational assessment of major crops. The initial efforts were made by ISRO, academia and Ministry of Agriculture under project titled Crop Acreage and Production Estimation (CAPE) and later ISRO formulated Forecasting Agricultural Output using Space, Agro-meteorology and Land-based Observations (FASAL) project. ISRO has transferred the methodology of FASAL and National Agricultural Drought Monitoring Assessment Project to Mahalanobis National Crop Forecast Centre (MNCFC) under Ministry of Agriculture and Farmers Welfare. Currently, MNCFC gives multiple, pre-harvest crop production forecasts for 8 crops (Rice-kharif & rabi, wheat, rapeseed & mustard, potato, jute, sugarcane, cotton and sorghum-rabi). It also carries out National Agricultural Drought Monitoring Assessment Project and a host of pilot projects related to crop insurance, micro irrigation, crop intensification, horticulture projects etc with technical support from ISRO. The new sensors of ISRO are also planned keeping the evolving needs of various ministries in view.

A major initiative in the country is Watershed Development Programme which aims at conservation of soil and water resources in the rain fed area for enhancing agricultural production, ensuring livelihood security. The IRS data have been used for integrated development of land and water resources, and assess the improvements of the treated watershed. The Integrated Mission for Sustainable Development (IMSD), National Watershed Development Programme for Rainfed Areas (NWDPRA) and Sujala Watershed Development Programme are some of the well-known projects which received recognitions both at national and international level.

High resolution, multi-temporal satellite data of IRS is also used for monitoring the irrigation infrastructure development. One such programme was Accelerated Irrigation Benefit Programme (AIBP) which was joint activity of ISRO and Ministry of Water Resources. In this potential created was assessed and online monitoring of about 150 ongoing projects through ISRO-Bhuavn platform is being carried out for monitoring progress, identification of critical gaps for prioritization of work etc. Hydrological studies were given due attention because of the availability of improved and newer sensors. Apart from mapping of water bodies for user agencies, a water spread map is being regularly generated by NRSC and is available on Bhuvan. Flood affected region in India is detected using SCATSAT-1 & SARAL/Altika in near real time basis. Research on satellite based Hydrological Model which simulates surface water balance (Runoff, Infiltration ET, Soil Moisture, Snow melt etc.) using satellite inputs over India at 5x5 km Grid is being carried out at SAC. Some of these inputs are very much sought of data for agricultural planning and policy decisions. With the inclusion of SWIR band in IRS satellites, periodic inventory of snow and glaciers is being carried out. Glacier facies maps for ~ 1400 glaciers was generated using RISAT Scenes for the year 2015-16 and products are made available to users through VEDAS. Shoreline Change Atlas of the Indian Coast using LISS-IV data on 1:25K) was also generated. IRS data was extensively used for identification of potable ground water sources in terms of depth and yield and also in identifying suitable sites for constructing recharge structures. National Drinking Water Mission project was carried out covering the entire country and maps used by State line departments to select suitable sites for drilling wells.

IRS data has helped in planning at gross root level in many ways. Under Space Based Information Support for Decentralized Planning (SISDP) project, primarily LISS-IV data was used for natural resource database at 1:10000 for strengthening decentralized planning and decision making at grass root level. This empowers the local bodies for planning. At the same time, ISRO has initiated Empowering Panchayati Raj Institutions Spatially (EPRIS) - an outreach programme to build the capacity of grass root-level planners.

Over the years, IRS data was extensively used for addressing the various aspects of Disaster Management Support (DMS) activities. The inputs of satellite communication, satellite remote sensing, and meteorology are used respond to a disaster situation depending on the need. The IRS series are extensively used for natural disasters viz., Flood, Cyclone, Forest Fire, Earthquake and Landslide through dedicated Decision Support Centre (DSC) established at NRSC, Hyderabad. The Early Warning systems developed for flood situation of the country is monitored using Optical and Microwave remote sensing data. Some of the examples are J&K floods (2014), Chennai Flood (2015) and Assam Floods (2016). Cyclogenesis, cyclone tracking and land fall prediction form part of DMS. The space derived inputs were used during Cyclone PHAILIN in 2013, cyclone

HUDHUD in 2014 and cyclone VARDAH in 2016 for tracking and landfalls prediction.

The formation of National Natural Resources Management System (NNRMS), a well-knit multi-pronged implementation architecture network, involving central & state Governments, private sectors, academia and Non-Governmental Organizations is in place for enabling the integration of Remote Sensing, contemporary technologies and conventional practices for management of natural resources. It was established in 1985 under the aegis of Planning Commission and with Dept. of Space as nodal agency. It envisages use of RS data as a cornerstone for the survey and management of natural resources in the country along with other collateral data. There are several state, central govt. agencies, academic institutes and voluntary agencies who are engaged in utilizing space technology in the country. Parallely, infrastructure for training and education has been established in the country. Various centres for providing infrastructure facilities for data analysis and value added services have also been established. RS data is being routinely used in many areas of survey and management of natural resources. Currently there are nine Standing Committees (SC) of various themes which meet periodically and review the progress of the remote sensing application projects. During the last three decades, the NNRMS-SCs have provided required impetus for utilisation of data from IRS missions through projectization and review guidance.

Geospatial platforms and Information Systems links the data and technology developers with the stake holders. ISRO has ensured the outreach, dissemination, education and start-ups initiations in the country. The dissemination services improved with ISRO starting web based portal such as MOSDAC (Meteorological & Oceanographic Satellite Data Archival Centre), BHUVAN, for Indian Earth Observation Data Visualization, National Information System for Climate and Environment Studies (NICES), BIS for Biodiversity Information, India-WRIS for water resources information and Visualisation of Earth Observation Data and Archival System (VEDAS). The early warning systems and its dissemination necessitate state-of-the-art-web portals and dashboards. The ISRO's enhanced engagement with line department has resulted in institutionalisation or internalisation of remote sensing techniques within their department. ISRO, through its proactive efforts, has ensured the capacity building of user departments, private entrepreneurs and academia. The IIRS and IIST are involved in human resources development in various spheres of Space Technology Applications.

The governance and development needs Space Technology based tools for efficient management. Towards enhancing this, interaction of ISRO with various Ministries/ Departments in 2015 resulted in newer demands and formation of about 159 projects across 58 Ministries/ Departments. Many of the space-based applications provide valuable inputs to flagship programmes of the Government. ISRO has planned various suites and constellation of satellite for the future to meet the ever growing demands.

In conclusion, the three decades of IRS satellites, its data and applications has demonstrated the vision and strength of ISRO's capabilities. The outcome of this is very much evident in its usage by policy makers at various levels and demand for more and more products and services. This has further augured ISRO to provide continuity and improved space infrastructure, development of application techniques, products and services. Now the nation looks at ISRO as an important asset and expects more and more while the global community likes to be on-board with ISRO.

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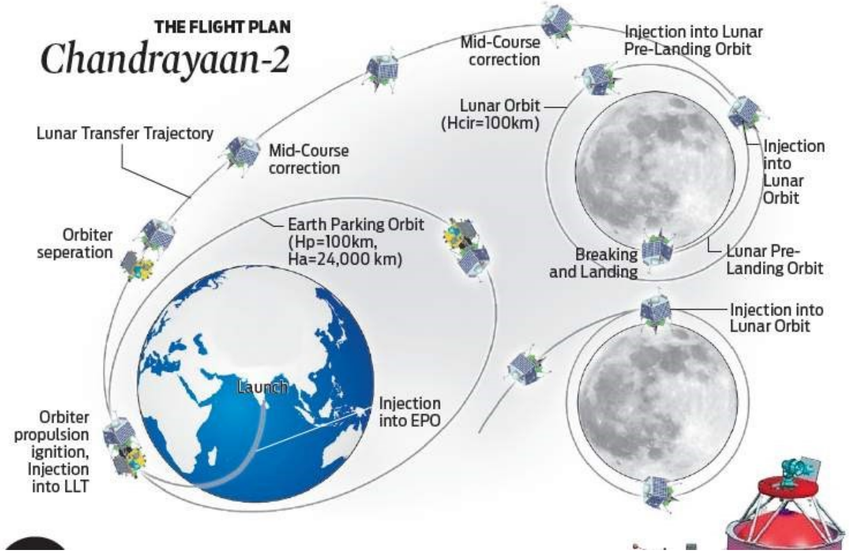
News and Snippets

ISRO to launch Chandrayaan 2: India's second mission to Moon in January 2019

India's second lunar mission to Moon 'Chandrayaan 2' is now scheduled to launch in January 2019. It has been developed indigenously by ISRO. It consists of Orbiter, Lander and Rover configuration. In this mission, for the first time, landing a rover on moon's south pole will be attempted by ISRO. The soft landing on the lunar surface of the moon will be the most complex part. Presently, only the US, Russia and China are the countries who have been able to soft-land spacecraft on lunar surface. China is also planning to launch a lunar probe in 2018 to achieve world's first soft landing on the far side of the moon to showcase its ambitious space programme including manned missions, building permanent space station and reaching to Mars.



Android App - Solar Calculator for Africa developed by SAC, ISRO

An android app has been developed by Space Applications Centre (ISRO) at the behest of International Solar Alliance (ISA). The app was launched on June 4, 2018 at Vigyan Bhavan, New Delhi by Minister of Power in presence of Ambassador of France and Director General of International Solar Alliance. Some of its salient features are like this: it provides solar energy potential (kWh/m2) at any given location, required location can be keyed in or can be obtained through GPS, it gives monthly and yearly Solar Potential processed using Satellite data, it also offers monthly minimum and maximum temperature to calculate realistic solar potential, the location is displayed on image with satellite data in the background. it also gives azimuth & elevations angles and day length over different time periods in a year, obstruction of sunlight due to terrain is also calculated using DEM, it also suggests optimum tilt angle for Solar PV installation and complete report can also be saved as a PDF file.

Satellite Laser to map forests in 3-D

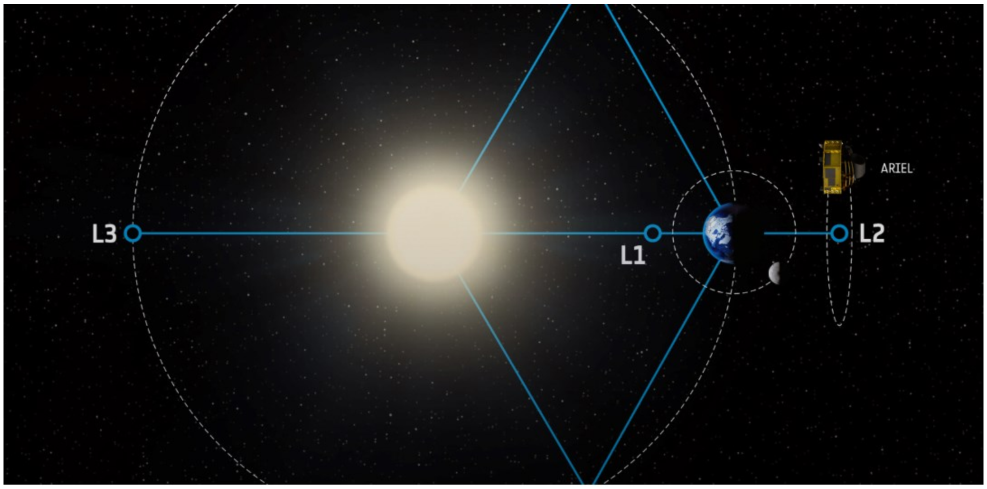
Source: https://www.scientificamerican.com/article/satellite-laser-will-map-forests-in-3-d/

Measurement of the intricate structure of forests by satellite lasers will soon be a reality. In 2018, NASA will be sending a laser into the galaxies to assess the world's trees, named as Global Ecosystem Dynamics Investigation Lidar (GEDI). The GEDI instrument is a geodetic-class, light-detection and ranging (lidar) laser system comprised of 3 lasers that produce 10 parallel tracks of observations. Each laser fires 242 times per second and illuminates a 25 m spot (a footprint) on the surface over which 3D structure is measured. Each footprint is separated by 25 m along track with an across-track distance of about 600m between each of the 10 tracks. By combining data on how much carbon is stored in wood with GEDI experiments, researchers will be able to compile a solid estimate of the carbon stored in the forests for the first time. GEDI will be installed on the International Space Station in late 2018.

ARIEL: First space mission dedicated to exoplanet atmospheres

Source: www.astrowatch.net

The ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey) mission will carry out the first ever large-scale survey of exoplanets. This European Space Agency's new mission will focus on discovering new worlds outside of our solar system. Ariel will address the fundamental questions on what exoplanets are made of and how planetary systems form and evolve by investigating the atmospheres of hundreds and planets orbiting different types of stars, enabling the diversity of properties. It is expected to launch in 2028.



A new global geospatial dataset for agriculture and food security

Source: https://www.geospatialworld.net/blogs/new-global-geospatial-dataset-for-agriculture/

Evaporative Stress Index (ESI), a new global geospatial dataset for agriculture and food security has been released around the world. It is a joint initiative of the National Aeonautics and Space Administration (NASA) and United States Agency for International Development (USAID), known as SERVIR. The index captures early signals of "flash drought", a condition brought about by rapid rise in temperature, leading to drying up of the air, reduced rainfall and moisture evaporating quickly from the soil. By properly monitoring the rate of water loss through the use of land surface temperature before, this index will help in taking appropriate remedial measures before the condition actually starts having an effect on the vegetation.

To download ESI data as tif files, go to
https://gis1.servirglobal.net/data/esi/

India's Desi GPS: NavIC

Indian Space Research Organisation (ISRO) has deployed an indigenous regional positioning system named as "Navigation with Indian Constellation" (NavIC). It consists of seven satellites in a constellation to provide Position, Navigation and Timing (PNT) services in Indian mainland and surrounding region up to 1500 Km. NavIC, whose seventh satellite was launched in April 2016, was expected to provide India a satellitebased navigation system independent of the U.S.-controlled GPS (Global Positioning System). It provides two types of services viz. Standard Positioning Service (SPS) and Restricted Service (RS). While the space and ground segment of the NavIC system has been established and demonstrations of various applications/ services have been conducted, the time required for it to become fully operational depends on the service providers making the services available in the market. IRNSS-1I launched on April 12, 2018, is the eighth satellite to join NavIC navigation satellite constellation. ISRO is now working towards further miniaturisation of the chipset to be used in very small navigation devices. ISRO also has a plan to put desi atomic clock on-board the navigation satellite. Space Applications Centre has developed an indigenous atomic clock, and this clock is currently undergoing a series of qualification tests. Once it successfully clears all tests, the desi atomic clock will be used in an experimental navigation satellite to test its accuracy and durability in space. At present, the space agency currently imports atomic clocks from European aerospace manufacturer Astrium for its navigation satellites., the design and technology of which is currently not known to ISRO. With the development of the desi atomic clock, ISRO has become one of the few space organizations in the world that have gained the capability to develop this highly sophisticated technology.

First Light: Fourth U.S. Air Force SBIRS Satellite Sends First Images Back to Earth

Source: www.astrowatch.net

The U.S. Air Force's fourth Space Based Infrared System (SBIRS) satellite launched on January 19 this year, transmitted its first images back to Earth. The milestone, known as "first light," occurred in February 2018 when the SBIRS GEO Flight-4 satellite, built by Lockheed Martin, turned on its powerful sensors for the first time during space vehicle checkout. SBIRS GEO Flight-4 is the latest satellite to join the Air Force's orbiting missile warning constellation. Equipped with powerful scanning and staring infrared surveillance sensors, the satellite collects data for use by the U.S. military to detect missile launches, support ballistic missile defense, expand technical intelligence gathering and bolster situational awareness on the battlefield.

Chinese mission for Global Navigation services

China plans to form a Beidou network consisting of constellation of 35 satellites for global navigation services by 2020. It is expected to compete with US's Global Positioning System (GPS).

NMDC and ISRO joined hands to promote Space exploration in exploration and mining activities

http://business-standard.com

NMDC and NRSC (ISRO), Department of Space, Government of India joined hands through a MoU to Promote Space Applications in exploration and other mining activities for "Satellite Based Geological Mapping and Multidisciplinary Exploration of Iron, Diamond and other mineral deposits", which is a step forward towards "Digital India" as Space Technology provides real-time data for generation of digital maps "Remote Sensing & GIS Lab" at Hyderabad has been inaugurated by NMDC on 02 May 2018. NRSC and NMDC have developed a Mobile App to collect field data with location and field photo and catalogue to collect geological information and for viewing in "BHUVAN PORTAL". This App is presently being used by NMDC in its Sidhi-Singrauli Iron Ore Block and Chattarpur & Damoh Diamond Blocks for field data collection and has proved to be very useful. NMDC is using MOBILE GIS studies using above APP and "Bhuvan Platform" in all its exploration programmes.

India to train scientists of countries lacking satellite-building capability

India has decided to train space scientists of countries that lack satellite-building capability. The country announced this initiative during the UNISPACE+50 meeting in Vienna recently. India will also launch the satellite built by ISRO-trained scientists of a country if the spacecraft is well-built and clears all tests. The Indian delegation led by ISRO chairman K Sivan at the four-day summit from June 18 also had bilateral talks with space scientists of 12 countries, including France, Israel and Japan, on the sidelines of the meeting. The talks focused on enhancing space collaboration. India won’t charge for this capacity-building programme but will play a role in shortlisting scientists for the training programme.

Society Activities –2017-2018

Indian Society of Geomatics –Ahmedabad Chapter (ISG-AC) Activities

Dr. C. P. Singh
(Secretary, ISG-AC: Term 2017-20)

July 22, 2017

Outreach Programme at M.N. SCIENCE College, Patan

As part of outreach activity, the programme entitled '**Geomatics: An instructional tool**' was conducted at Patan on July 22, 2017, which involved around 70 college students. On this occasion, lectures were delivered by Dr. Prakash Chauhan, Dr. Alpana Shukla and Dr. C.P. Singh. For the benefit of students, the lectures were especially delivered in Hindi and Gujrati language. Students were highly benefitted by the lectures and interactions covering future avenues in the field of Geomatics education.

August 12, 2017

Popular Lecture at MG Science Institute, Ahmedabad

On the occasion of Dr Vikram Sarabhai's birthday, eminent Space Scientist Prof. Narendra Bhandari was invited for a popular talk on "Falling Stones & Secrets of the Universe" on August 12, 2017. The event arranged at GIDC Bhavan, was well-attended by professionals and more than 150 students. Dr Bhandari shared his research experiences, which was highly motivational for the youngsters .

September 02, 2017

National Remote Sensing (NRS) Day Celebration in CEPT University, Ahmedabad

Remote sensing day was celebrated at CEPT University on Sept 2, 2017. The event received overwhelming response from nearly 250 Under Graduate & Post Graduate students from Gujarat University, MG Science Institute and CEPT University. A full day event included activities like Origami, quiz and visit to VSSE. Dr. Raj Kumar, Deputy Director, EPSA, SAC, ISRO gave valedictory remarks followed by prize distribution to the winners.

September 09 , 2017

World Ozone Day Celebration– at GMIS, Ahmedabad

Every year, 3rd Saturday in the month of September is globally celebrated as World Ozone day. However, the program was organised by ISG-AC at Global Mission International School at Sanskar Dham (Bopal-Godhavi road) on September 09, 2017 due to their academic schedule. Dr Mehul Pandya (SAC) was invited to deliver a talk on “Role of Space Science in Ozone and Earth Observation. It was attended by 450 students from class 6 to 12. Many ISG-AC members also participated and answered to the queries of students.

September 16 , 2017

One-day workshop on “Introduction to Remote Sensing and GIS for Civil Engineering Applications” at L.D. College of Engineering, Ahmedabad

One-day workshop on “Introduction to Remote Sensing and GIS for Civil Engineering Applications” was organised in collaboration with L.D. College of Engineering and IEEE Geoscience and Remote Sensing Society Gujarat Chapter during September16, 2017 with various lectures by eminent speakers from PRL and ISRO. The lectures covered, Basics of remote sensing and Applications, Basics of microwave remote sensing and applications, Basics of GIS and applications, Satellite based surveying techniques and Applications of Satellite data in Hydrological Modeling. Around 50 professionals, mostly faculty and research scholars from various institutions in Gujarat participated in the Workshop. Participation certificates were distributed to all the participants at the end of the workshop. The workshop was highly appreciated by the participants. The participants expressed their interest for similar training workshops in future involving more applications using the technology.

September 22, 2017

National Seminar at Gujarat University, Ahmedabad

One-day seminar on Applications of Geospatial Technology for Sustainable Development was organised in collaboration with Department of Geography, Geology and Geoinofrmatics of Gujarat University during September 22, 2017. More than 150 participants from various universities and colleges gathered for the seminar. The seminar provided an excellent platform and opportunity to the students, researchers, practitioners and entrepreneurs to update their knowledge on Geospatial Technology, research ideas and Applications of such technology in achieving sustainable development goals.

November 10, 2017

Popular Lecture on "Semantics Enabled Framework for Mining Large Remote Sensing Data Archives" at SAC, Ahmedabad

A Popular Lecture on "Semantics Enabled Framework for Mining Large Remote Sensing Data Archives" by Dr. Surya Durbha, Associate Professor, CSRE, IIT Bombay, Powai, Mumbai was organised by ISG-AC during November 10, 2017 at SAC and it was well received by ISG members and scientists at SAC. It was attended by around 80 participants.

November 11, 2017

GIS Day and GIS Week Celebration

GIS Day was organised by Geomatics Programme, Faculty of Technology, CEPT University, Ahmedabad in Collaboration with Indian Society of Geomatics, Ahmedabad Chapter during November 11, 2017, followed by GIS Week (till November 15, 2017) during which series of expert lectures were organised. Events like story maps, spatial thinker, memory game, treasure hunt, geo quiz, debate, puzzle (jigsaw), pin it, find me if you can, map design contest and 3D map modeling were also organised. It was 10th Anniversary of GIS Day at CEPT University as they have been celebrating GIS Day since 2007. A webpage (http://cept.ac.in/events/international-gis-day) was made operational for this event.

Dr. R. Nandakumar Ex-Senior Scientist, SAC, ISRO and active ISG member contributed in the GIS Day celebration along with Prof. Anjana Vyas, Adjunct Professor, Faculty of Technology & Executive Director, CEPT and Ms. Shubhangi Mane, Senior Technical support executive, ESRI India. Dr Nandakumar delivered a lecture on “Software Quality with Geospatial Examples”. Ms. Mane delivered her talk on “New trends in GIS”. More than 7 colleges and 2 schools participated, making a total of 95 participants, of which 75 were students, 15 alumni of CEPT University and 5 researchers. These include H K Arts College, Adani University, Parul College, Anant University, EDI, RSAC (U.P.), Gujarat University, Udgam and Anand Niketan schools respectively.

Poster competition based on the basic understanding of GIS were the participants were given freedom to draw and explain their understanding of GIS. In this competition both school and college students made hand drawn posters explaining their view of GIS. In total 40 students took part in the competition. Debate competition participants were divided in to teams and were given topics on which they speak for or against the topic. For this each team made of four students from which two spoke for and two spoke against the topics given on current trends in GIS like “GIS: New Science or Old Wine”. four teams participated in the event. A period of five minutes was given to think upon the topic. In total five minutes was given to each team to speak for and against the topic. The medium of communication was Hindi, English or Gujarati. The participants were judged on the choice of points, confidence, pronunciation & enunciation, grammar, choice of words and body language.

In the treasure hunt game, the goal was to educate the students about GPS and space. GIS based treasure was planned in which the participants were exposed to the GPS technology to find the treasure hidden in the CEPT campus with the help of geographical clues. Four teams participated in the event with 6 participants in each team having both school and college students. One of the team reached the treasure by cracking all the hints.

Pictionary was also organised which is a word game wherein the participants are grouped in the group of two. One of the participant is given a word related to Geospatial Technology which had to be explained to the other participant of the team by drawing it to the board within 15 seconds. The game was played in two levels; easy, and hard. In total 14 teams participated. The words chosen for the event were all related to remote sensing, space and earth sciences. Teams were judged based on the time individually. Students Ideas and Innovations on

December 28, 2017

Popular lecture at GIDC Bhawan, Ahmedabad

ISG-AC organised a popular lecture on "Exploiting Petabyte Scale EO Data: A Data Cube Approach" by **Shri T. T. Medhavy, Director EO Science at Geoscience Australia** during December 28, 2017 at GIDC Bhavan, Besides M.G. Sci. Institute, Ahmedabad which was well received by the students and ISG-AC members. Around 80 students took part in this event

December 26-31, 2017
April 9-14, 2018

Teachers' Training Programs at M.G. Science Institute

Dr. Alpana Shukla, Head, Botany Department, M. G. Science Institute and Vice-Chairperson, ISG-AC, successfully organized TWO week-long Teachers' Training Programs, in December 2017 and during April, 2018. These trainings were sponsored by ISRO Headquarters and supported by SAC-ISRO as well as ISG-AC. Twenty teachers took part in the first one and 21 teachers from Physics, Botany, Environmental Science, etc., representing various universities of Gujarat like Gujarat University, Hemchandracharya North Gujarat University, Veer Narmad South Gujarat University and Kutch University, participated in the second training. The trainings included theoretical as well as practical aspects of basics of remote sensing and GIS. The Program content included fundamentals of remote sensing, applications of space technology in recent times, especially in Ecosystem management, visual interpretation of satellite images, digital image processing, basics of GIS and its applications in various domains, applications of GPS and opportunities in Geomatics and geoinformatics. Hands on training sessions were conducted for participants, which included introduction to web portals like BHUVAN and VEDAS, satellite data downloading, opening images of various formats in advance software like ENVI and QGIS, classification of various features by supervised and unsupervised methods and overlying shape files and boundaries on the image files. All the theory and hands on training sessions were carried out by expert scientists from ISG, SAC, MGScience and senior most faculties from different institutes and research fellows. Visit to VSSE was the highlight of these training programs.

February 3-4, 2018

Educational Excursion at Mundra Port

An environmental educational excursion to Mundra Port was jointly organised by ISG-AC and IMSA for its members during 03 – 04 February, 2018 (Saturday-Sunday). Total 72 members from ISG-AC and IMSA participated. Upon reaching Ahmedabad to Mundra port (351 km) members were received and felicitated by Adani officials and Video show on Adani group was followed by visit to Adani Port & SEZ, Adani Wilmar Ltd., Shantinath Mahadev Aarti and cultural programme / activities by members and their family members.

Next day visit to West Port and Adani Power Ltd. was conducted and thereafter departed by Bus for Ahmedabad. The educational excursion was highly appreciated by all the members. Members were presented with a memoir (wooden key ring) having logo of both the society.

June 05, 2018

World Environment Day (WED) Lecture at SAC, Ahmedabad

Indian Society of Geomatics – Ahmedabad Chapter in collaboration with Indian Society of Remote Sensing – Ahmedabad Chapter organised a lecture on the occasion of World Environment Day (WED) – 5 June, 2018. Dr. H.G. Sadhu, Scientist, MD (Gen Med), AFIH from ICMR - National Institute of Occupational Health, Ahmedabad delivered his lecture on “Challenges for Occupational and Environmental Health in India”. The lecture was organised at Vikram Hall, Space Applications Centre, Ahmedabad on 5th June, 2018 (15:30 hrs) and around 80 members attended the lecture.

From ISG Secretariat

ISG NEW LIFE MEMBERS

S.No.	Membership No.	Name	Name & address
1	ISG-L-1846	Prof. H.B. Raghavendra	Director, School of Technology, PDPU, Gandhinagar, Gujarat
2	ISG-L-1847	Seerat Megray	Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
3	ISG-L-1848	Midhat Fayaz Shalla	Lecturer, Department of Earth Sciences, Srinagar, Jammu & Kashmir
4	ISG-L-1849	Dr Rakesh Chandra	Sr. Assistant Professor, Department of Earth Sciences, Srinagar, Jammu & Kashmir
5	ISG-L-1850	Dr Farooq Ahmad Dar	Assistant Professor, Department of Earth Sciences, Srinagar, Jammu & Kashmir
6	ISG-L-1851	Omar Jaan	Research Scholar, Department of Earth Sciences, Srinagar, Jammu & Kashmir
7	ISG-L-1852	Aamina Sultan	Research Scholar, Department of Earth Sciences, Srinagar, Jammu & Kashmir
8	ISG-L-1853	Jhokar Subiaya Bashir Bashir	M.Sc. Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
9	ISG-L-1854	Jasia Bashir	Research Scholar, Department of Earth Sciences, Srinagar, Jammu & Kashmir
10	ISG-L-1855	Aneaus Shakil	M.Sc. Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
11	ISG-L-1856	Anjum Shafi Zsani	Student, Department of Earth Sciences, Srinagar, Jammu & Kashmir
12	ISG-L-1857	Govinda Rajul K.	Sci./Engr.'SF', SAC, ISRO, Ahmedabad, Gujarat
13	ISG-L-1858	Sr. Tejaskumar P. Thaker	Assistant Professor, Pandit Deendayal Petroleum University, Vadodara, Gujarat
14	ISG-L-1859	Shahid Gulzar	Associate Professor, COWI India Ltd., Delhi
15	ISG-L-1860	Sarah	DST-Inspire Faculty, University of Kashmir, Srinagar, Jammu & Kashmir
16	ISG-L-1861	Bilal Ahmad Wani	Student, Department of Earth Sciences, KU, J & K
17	ISG-L-1862	Ubair	M Sc. Student , Geoinformatics , HARSAC, HISAR, Haryana
18	ISG-L-1863	D. Hariprasad	Associate Professor, College of Engineering, Hyderabad
19	ISG-L-1864	Debabrata Nandi	Lecturer, North Orissa University, Takatpur, Orissa
20	ISG-L-1865	Dr. Kakoli Saha	Assistant Professor, SPA, Bhopal, Bhopal, MP
21	ISG-L-1866	Abhishek Anand	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
22	ISG-L-1867	Inderpret Kaur Grewal	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
23	ISG-L-1868	Arvind Kumar	Research Fellow, Punjab Remote Sensing Centre, Ludhiana, Punjab
24	ISG-L-1869	Gurpreet Kaur	JRF (Chemical Analyst), Punjab Remote Sensing Centre, Ludhiana, Punjab
25	ISG-L-1870	Harleen Kaur Vohra	JRF, Punjab Remote Sensing Centre, Ludhiana, Punjab
26	ISG-L-1871	Richa Sharma	JRF (Chemical Analyst), Punjab Remote Sensing Centre, Ludhiana, Punjab
27	ISG-L-1872	Reenu Sharma	Scientist, Punjab Remote Sensing Centre, Ludhiana, Punjab
28	ISG-L-1873	Lakhvir Singh	Research Associate, Punjab Remote Sensing Centre, Ludhiana, Punjab

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
29	ISG-L-1874	Shivani Singh	Research Associate, Punjab Remote Sensing Centre, Ludhiana, Punjab
30	ISG-L-1875	Anchal Kumar Jain	Professor, Punjab Remote Sensing Centre, Ludhiana, Punjab
31	ISG-L-1876	Rajni Sharma	Professor, Punjab Remote Sensing Centre, Ludhiana, Punjab
32	ISG-L-1877	Dr. Harmeet Singh	Professor, Punjab Remote Sensing Centre, Ludhiana, Punjab
33	ISG-L-1878	Anand R.	Assistant Professor, Easwari Engineering College, Ramapuram, Chennai,Tamil Nadu
34	ISG-L-1879	Dr. Ramesh Indirani	Assistant Professor, Tamilnadu Agriculture University, Madurai, Tamil Nadu
35	ISG-L-1880	Ms. Arti Sarkar	Sci./Engr.'SG', SAC, ISRO, Ahmedabad, Gujarat
36	ISG-L-1881	D. K. Das	Associate Director, SAC, ISRO, Ahmedabad, Gujarat
37	ISG-L-1882	Dr. Plya Kesava Rao	Assistant Professor, NIRD & Panchayati raj, Rajendranagar, Hyderabad, Telangana
38	ISG-L-1883	Sejal S. Bhagat	Assistant Professor, SCET, Surat, Gujarat
39	ISG-L-1884	Bhasker Vijaykumar Bhatt	PG Incharge & Asst. Professor, CED, SCET, Surat, Gujarat
40	ISG-L-1885	Jamakuwala Daisy	Adhoc Assistant Professor, College of Engineering & Technology, Surat, Gujarat
41	ISG-L-1886	Riddhi Dalal	M. Tech Student (Urban Planning), SUNIT, Surat, Gujarat
42	ISG-L-1887	Upasana Nitin Panchal	B.E. Student (Civil), ICEA, Surat, Gujarat
43	ISG-L-1888	Zarana Hitesh Gandhi	Adhoc Assistant Professor, SCET, Surat, Gujarat
44	ISG-L-1889	K. Venkateswaran	Assistant Professor, Kongu Engineering College, Perunderai
45	ISG-L-1890	Dr. N. Kasthuri	Professor, Kongu Engineering College, Perunderai, Tamil Nadu
46	ISG-L-1891	Venkata Ramana Murthy B.	Assistant Professor, BITS-VIFAG, Visakapatunam, Andhra Pradesh
47	ISG-L-1892	Dr. S.Jayakumar	Assistant Professor, Pondicherry University, Pondicherry, Tamil Nadu
48	ISG-L-1893	Dr. Suja P. Devipriya	Assistant Professor, Pondicherry University, Pondicherry
49	ISG-L-1894	Dr. R. Arun Prasath	Assistant Professor, Pondicherry University, Pondicherry
50	ISG-L-1895	Dr. K. N. Kusuma	Assistant Professor, Pondicherry University, Pondicherry
51	ISG-L-1896	Dr. Selvalakshmi S.	Professor, Pondicherry University, Pondicherry
52	ISG-L-1897	Dr. Ramaya K.	Professor, Pondicherry University, Pondicherry
53	ISG-L-1898	Satyam Verma	Professor, Pondicherry University, Pondicherry
54	ISG-L-1899	Kuimi T. Vashum	Ph. D. Scholar, Pondicherry University, Pondicherry
55	ISG-L-1900	Ajeet Kumar Singh	Ph. D. Scholar, Pondicherry University, Pondicherry
56	ISG-L-1901	Sathya M.	Ph. D. Scholar, Pondicherry University, Pondicherry
57	ISG-L-1902	Swapna Sarika Khadenga	Ph. D., Pondicherry University, Pondicherry
58	ISG-L-1903	Dr. Jayamohan J	Professor, Civil Engg. Dept., LBSITIN, Trivendrum
59	ISG-L-1904	Mohammed Ali Feroze Khan	Senior Survey Engineer, AECOM, Doha, Qatar
60	ISG-L-1905	Dr. P. Jambulingam	Director, ICMR, Puducherry

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
61	ISG-L-1906	Dr. S. Sabesan	Scientist, VCRC (ICMR), Puducherry
62	ISG-L-1907	Dr. S. Subramanian	Scientist, ICMR, Puducherry
63	ISG-L-1908	Mrs. A. Srividya	Scientist, ICMR, Puducherry
64	ISG-L-1909	Dr. K. Hari Kishan Raju	T.A., VCRC (ICMR), Puducherry
65	ISG-L-1910	Chirag Shailesh Shastri	Executive Director, CHDI, Ahmedabad, Gujarat
66	ISG-L-1911	Sneha Susai John	GIS System Analyst, Puducherry Water Resources Organisation, Puducherry
67	ISG-L-1912	Dr (Mrs) Phibankhamti Ryngnga	Asst. Professor, North Eastern Hill University, Shillong
68	ISG-L-1913	D. Naresh	Assistant Professor, S. T. Martin's Engineering College, Hyderabad
69	ISG-L-1914	Alajangi Simhachalam	Faculty, NIRD&PR, Assam
70	ISG-L-1915	Subitha.L	Assistant Professor, Department of PSM, JIPMER, Puducherry
71	ISG-L-1916	Mahalakshmy T	Assistant Professor, Department of PSM, JIPMER, Puducherry
72	ISG-L-1917	Dr. Kollipara Padma Kumari	Professor, Jawaharlal Nehru Technological University, Kakinada, Andhra Pradesh
73	ISG-L-1918	Rana Amitkumar Venilal	Assistant Professor, BMCARP, Surat, Surat, Gujarat
74	ISG-L-1919	Patel Chetankumar Ramanlal	Assistant Professor, S.V.N.I.T, Surat, Surat, Gujarat
75	ISG-L-1920	Tailor Ravin Maheshku-mar	Assistant Professor, S.V.N.I.T, Surat, Surat, Gujarat
76	ISG-L-1921	Parikh Hina Jaydeep	Town Planner, Design Ican, Surat, Surat, Gujarat
77	ISG-L-1922	L Balaji	CMD, Geomatics AERO Technologies Pvt. Ltd., Tamil Nadu
78	ISG-L-1923	Dr G Muthu Sankar	Head of GIS, French Institute of Pondicherry, Pondicherry
79	ISG-L-1924	Parmar Manish	Sci./Engr. 'SD', SAC, ISRO, Ahmedabad, Gujarat
80	ISG-L-1925	Shirke Sunil Suresh	Director, Shirke Consultants, Pune, Maharashtra
81	ISG-L-1926	Dr Tripathi Shashank	Project Scientist, Remote Sensing Applications Centre - UP, Lucknow
82	ISG-L-1927	Duvvuru Rajesh	Research Scholar, Andhra University College of Engineer-ing, Andhra Pradesh
83	ISG-L-1928	Pandey Neha	JRF, BISR, Jaipur, Rajasthan
84	ISG-L-1929	Babu Neela Victor	Professor & Principal , Baba Institute of Technology and Sciences, Visakhapatnam
85	ISG-L-1930	Nathani Beena H.	JRF, , Vadodara, Gujarat
86	ISG-L-1931	Pal Subhasree	Student, Symbiosis Institute of Geoinformatics, West Bengal
87	ISG-L-1933	Dr Kuttippurath Jayanarayanan	Assistant Professor, IIT, Kharagpur, Kharagpur, W.B.
88	ISG-L-1934	Das Pulakesh	Ph. D. Research Scholar, IIT, Kharagpur, West Bengal
89	ISG-L-1935	Jana Amit Kumar	Research Scholar, University of North Bengal, West Bengal
90	ISG-L-1936	Vekaria Girish L	Assistant Professor, Sir P.T. Science College, Modasa
91	ISG-L-1937	Sengar Sandeep Singh	Associate Professor, JKLU, Jaipur, Jaipur

ISG NEW LIFE MEMBERS (Contd.)

S.No.	Membership No.	Name	Name & address
92	ISG-L-1938	Pandey Arvind Chandra	Professor, Central University of Jharkhand, Jharkhand
93	ISG-L-1939	Tiwari Sharad	Scientist 'SF', Institute of Forest Productivity, Jharkhand
94	ISG-L-1940	Thakur Brahmanand Singh	Scientist-D, CGWB, Jharkhand
95	ISG-L-1941	Arvind Kumar	Director, Geological Society of India, Jharkhand
96	ISG-L-1942	Amit Kumar	Assistant Professor, Central University of Jharkhand, Jharkhand
97	ISG-L-1943	Jalem Kiran	Assistant Professor, Central University of Jharkhand, Jharkhand
98	ISG-L-1944	Parida Bikash Ranjan	Assistant Professor, Central University of Jharkhand, Jharkhand
99	ISG-L-1945	Saikia Purabi	Assistant Professor, Central University of Jharkhand, Jharkhand
100	ISG-L-1946	Parmar Kavita	DST-Young Scientist, Central University of Jharkhand, Jharkhand
101	ISG-L-1947	Binita Kumari	Research Scholar, Central University of Jharkhand, Jharkhand
102	ISG-L-1948	Gupta Saurabh Kumar	Junior Research Fellow, Central University of Jharkhand, Jharkhand
103	ISG-L-1949	Ahmad Tauseef	Junior Research Fellow, Central University of Jharkhand, Jharkhand
104	ISG-L-1950	Chaudhary Satendra Kumar	Research Scholar, Central University of Jharkhand, Jharkhand
105	ISG-L-1951	Stuti	Research Scholar, Central University of Jharkhand, Jharkhand
106	ISG-L-1952	Basheer Ahammed KK	Research Scholar, Central University of Jharkhand, Jharkhand
107	ISG-L-1953	Diksha	Research Scholar, Central University of Jharkhand, Jharkhand
108	ISG-L-1954	Tripathi Gaurav	Research Scholar, Central University of Jharkhand, Jharkhand
109	ISG-L-1955	Vashishat Nisha	Assistant Ornithologist, , Ludhiana
110	ISG-L-1956	Singh Sukhdeep	JRF, PRSC, Ludhiana, Ludhiana
111	ISG-L-1957	Baskey Tapati	JRF, PRSC, Ludhiana, Ludhiana
112	ISG-L-1958	Kaur Amanjot	JRF, ACM Division, PRSC, Ludhiana, Ludhiana
113	ISG-L-1959	Manish Kumar	JRF, ACM Division, PRSC, Ludhiana, Ludhiana
114	ISG-L-1960	Kanhaiya Lal	Assistant Professor, Central University of Jharkhand, Jharkhand
115	ISG-L-1961	S Balaselvakumar	Assistant Professor, Dept. of Geography, Periyar EVR College, Tiruchirappalli
116	ISG-L-1962	Tikader Sribash	Assistant Professor, Dept. of Geography, Micheal Madhusudan Memorial College, W.B.
117	ISG-L-1963	Joshi Veena	Professor and Head, Department of Geography, Pune
118	ISG-L-1964	M. Chinnamuthu	Research Scholar, Centre for Geoinformatics and Planetary Studies, Salem
119	ISG-L-1965	Pinank Rajendrakumar Patel	Assistant Professor , SSAIET, Navsari, Surat

National Symposium on

ADVANCEMENTS IN GEOSPATIAL TECHNOLOGY FOR SOCIETAL BENEFITS

and

ANNUAL CONVENTIONS

of

Indian Society of Geomatics (ISG)

&

Indian Society of Remote Sensing (ISRS)

with

Silver Jubilee Celebrations of the Indian Society of Geomatics

Celebrating Silver Jubilee 25 ISG 1993 – 2018

ISRS

December 05 - 07, 2018
SAC, Ahmedabad, Gujarat

Organized jointly by
ISG, Ahmedabad *and* ISRS, Dehradun

Hosted by
ISG, Ahmedabad Chapter (ISG-AC)
(www.isgindia.org)
ISRS, Ahmedabad Chapter (ISRS-AC)
(www.isrs-india.org)
and
Space Applications Centre, ISRO, Ahmedabad

Major themes:

Advanced Imaging Technologies (UAV, LiDAR, SAR, Hyperspectral), Advancement in sensor technologies, NAVIC and GNSS, Photogrammetry, 3-D Mapping, LiDAR, Virtual GIS, Big data Analytics, Data Mining, Cloud and Internet of things, Web & Location based Services (Tele-Geomatics, Mobile GIS), Spatial Data Infrastructure and Decision Support Systems, Physical Infrastructure development and Planning (Smart Cities), Sustainable Land Management and Infrastructure development, Agriculture/ Horticulture/ Water Resources Management, Forestry, Environment & Ecosystem Management , Wildlife habitat, Early signals of Climate Change and Mitigation Measures, Disaster Management, Weather Forecasting, Geospatial Technology for Renewable Energy Resources, Geoscience Applications, Planetary Exploration, Health GIS, Skill Development and Livelihood, Large scale mapping and e-governance, Archaeological Exploration and Heritage sites management, Coastal and Marine Applications, Cryosphere Science and Applications, Recent trends in Geoinformatics.

Call for papers:

The original unpublished research papers, covering one or more sub-themes are invited for presentation. Authors may submit abstracts within 300 words in the prescribed format online through the symposium website www.isgns2018.in. Manuscript of the full length papers as per the prescribed format of the Journal of Geomatics (www.isgindia.org) will be included in the softcopy proceedings. Abstract Volume and Proceedings of the Symposium shall be brought out in digital form and selected papers will be considered for publication in a special issue of Journal of Geomatics after the peer-review process.

SAC

Pre-Symposium Tutorials:

For training young professionals & students 5 thematic tutorials during Dec.03-04, 2018:
***Theme 1:** Applications of IRNSS & GPS in Navigation & Mapping,*
***Theme 2:** Planetary science and data processing,*
***Theme 3:** SAR data Processing and Applications,*
***Theme 4:** Big Data Analytics and Machine Learning,*
***Theme 5:** Sustainable Smart Cities: Geospatial Solutions*

Call for sponsorship:

Different sponsorship categories (Platinum, Diamond, Gold and Silver) & exhibition opportunities are available for Government and corporate sectors. For further information please contact: sponsor.isgns2018@gmail.com.

Registration fee:

	Early bird	After Oct.31, 2018
ISG/ISRS members	Rs. 3000	Rs. 3500
Non-members	Rs. 4000	Rs. 4500
Foreign participants	US $150	US $200
Students & Sr. Citizens (Members)	Rs 1500	Rs 2000
Students & Sr. Citizens (Non-Members)	Rs 2000	Rs 2500
Accompanying persons	Rs 1000	Rs 1500
Pre-symposium Tutorials	Rs 2000	Rs 2500

Important Dates to Remember:

Last Date for Abstract Submission	August 31, 2018
Intimation of Acceptance of Abstracts	September 30, 2018
Last Date for Tutorial Applications	October 15, 2018
Intimation of Admission into Tutorials	October 25, 2018
Registration for Commercial Presentations	October 31, 2018
Registration for Industrial Exhibition	October 31, 2018
Submission of Full Paper	October 31, 2018
Last Date for Registration to the Symposium	October 31, 2018
Last Date for Registration to the Tutorial	November 15, 2018
Last Date for Guest House/Hostel booking	November 30, 2018
Pre-Symposium Tutorials	December 03-04, 2018
National Symposium	December 05-07, 2018

For more details ▼

Symposium Website: www.isgns2018.in
e-mail : isgns2018@gmail.com
Telephone: +91 079 26914117; +91 079 26914024 / 6202

CONTACT:
Dr. C. P. Singh
Organizing Secretary - ISG National Symposium-2018
Room No. 4117, Space Applications Centre (SAC), ISRO
Ahmedabad - 380015, India
Phone: +91 79 2691 4117 / 4024 / 6202 (O)
Mobile: 09426353641, Fax: +91 79 2691 5823 / 5862
Email : secretary.isg2018@gmail.com

ISG

Indian Society of Geomatics

To,
The Secretary, Indian Society of Geomatics
6202, Space Applications Centre (ISRO)
AHMEDABAD – 380 058. INDIA

Sir,

I want to become a Member/ Life Member/ Sustaining Member/ Patron Member/ Foreign Member/ Student Member of the Indian Society of Geomatics, Ahmedabad for the year _____. Membership fee of Rs. _____ is being sent to you by Cash/ DD/ Cheque/Online. (In case of DD/ Cheque/ Transaction No.______________ dated________drawn on Bank ___________________). I **agree to abide by the Constitution of the Society.**

Date:

Place: **Signature**

Name: Mr/Ms/Mrs/Dr____

Address: ____

____PIN: ____________

Phone: _____________ Mobile: _______________Email: __________________________________

Date of Birth __________________________Qualifications__________________________________

Specialisation: ____

Designation: _______________________ Organisation. __________________________

Membership in other Societies: ______________________________________

Mailing Address: ____

____PIN: __________________

Proposed by:

(Member's Name and No)

Signature of Proposer

For Office Use: A/P/L Member No.		Receipt No.		Date:	

Indian Society of Geomatics (ISG), Room No. 6202 Space Applications Centre (ISRO), Ahmedabad-380058, Gujarat. Url: www.isgindia.org Phone: +91-79 26916202
Email: secretary@isgindia.org or sasharma@sac.isro.gov.in Fax +91-79-26916287

MEMBERSHIP FEES

S.No.	Membership	Life/Patron Membership fees		Annual Subscription
	Category	**INR** Indian	**US $** Foreign	**INR** Indian
1.	Annual Member	10	---	300
2.	Life Member a) Admitted below 45 years of age	2500	250	
	b) Admitted after 45 years of age	2000	200	
3.	Sustaining Member	---	---	2000
4.	Patron Member	50000	3000	---
5.	Student Member	10	---	100

MEMBERSHIP GUIDELINES

A Member of the Society should countersign application of membership as proposer.

Subscription in DD / Cheque should be made out in the name of 'Indian Society of Geomatics' and payable at Ahmedabad.

Online payment may be made to ISG account and transaction number may be intimated.

Bank: State Bank of India. **Branch**: Jodhpur Tekra, Ahmedabad

IFS Code: SBIN0003967 **Account No**:10327867093

Financial year of the Society is from April 1 to March 31.

For further details, contact Secretary, Indian Society of Geomatics at the address given above.

ISG has chapters already established at the following places. Ahmedabad, Ajmer, Bhagalpur, Bhopal, Chennai, Dehradun, Delhi, Hissar, Hyderabad, Jaipur, Ludhiana, Mangalore, Mumbai, Mysore, Pune, Shillong, Trichi, Srinagar, Vadodara, Vallabh Vidya Nagar, Visakhapatnam and Trivandrum. Applicants for membership have the option to contact Secretary/Chairman of the local chapter for enrolment. Details can be found at the website of the Society: **www.isgindia.org**.

Journal of the Society will be sent to Life Members by softcopy only.

Indian Society of Geomatics (ISG), Room No. 6202 Space Applications Centre (ISRO), Ahmedabad-380058, Gujarat. Url: www.isgindia.org Phone: +91-79 26916202
Email: secretary@isgindia.org or sasharma@sac.isro.gov.in Fax +91-79-26916287