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IEEE Gujarat Section Geoscience and Remote Sensing Society- Chapter Newsletter

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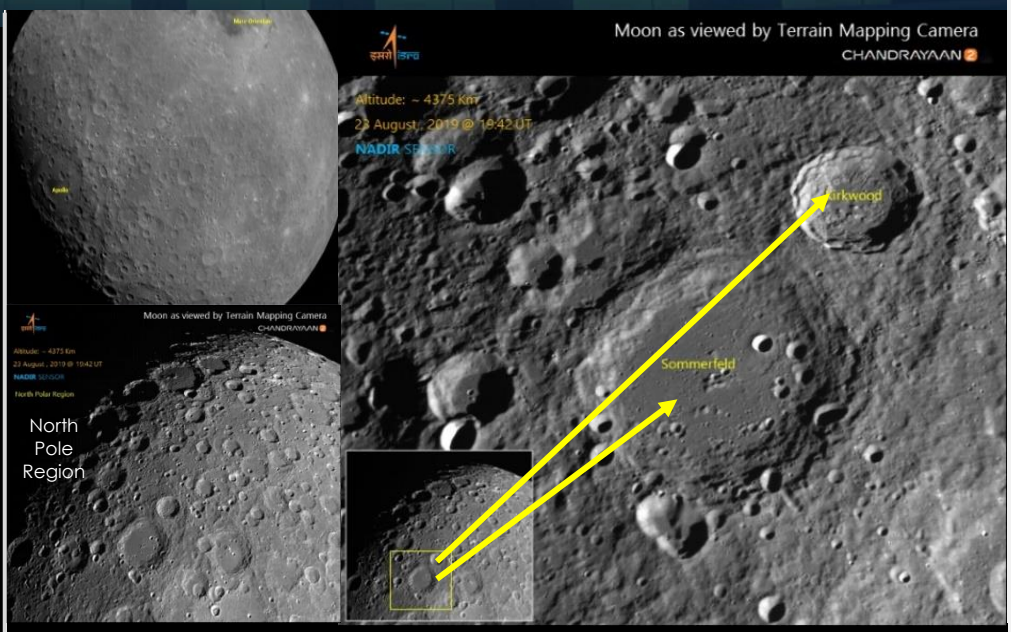
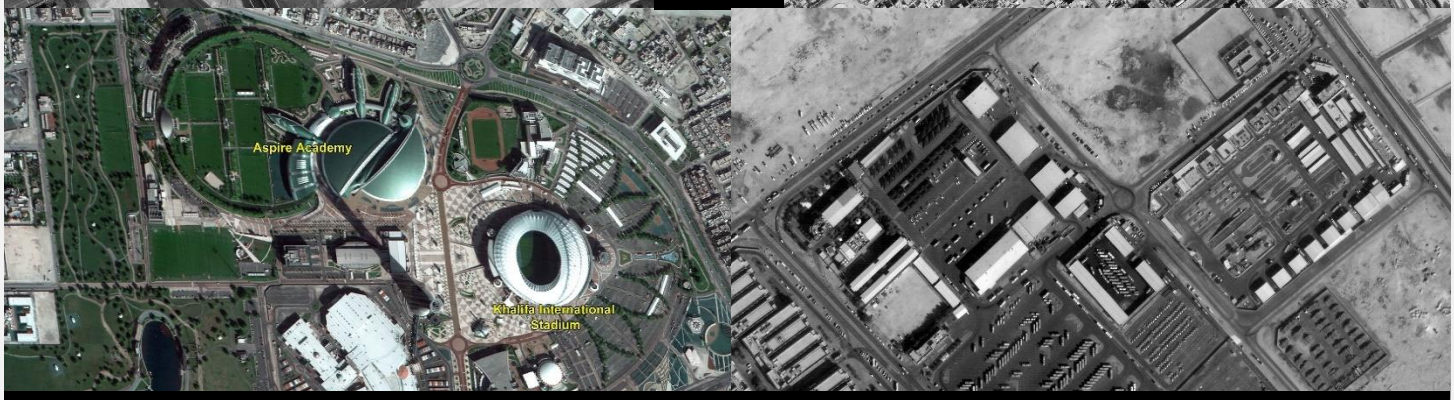


Moon as viewed by Chandrayaan-2 TMC Camera on August, 23 2019 19:42 UT: source: ISRO (isro.gov.in)

Old Doha Airport area (Left) and Palm City area, (Right) of Qatar as seen by High resolution Panchrom-atic camera of Cartosat-3 acquired on 28-Dec-2019 source: ISRO



Khalifa Stadium area, Qatar as seen by High resolution Multi-spectral Image (Left), and Dalla Driving Academy from High Resolution panchromatic camera of Cartosat-3 acquired on 28-Dec-2019 Source: ISRO

EXECUTIVE COMMITTEE

EDITORIAL COMMITTEE

From the Editors

We have great pleasure in bringing to you the 2019 e-newsletter of our IEEE Gujarat Section GRSS Chapter. Although it is delayed, we hope you'll find the contents useful to you in several ways. Our team has voluntarily put in their best efforts in compiling, editing, formatting and releasing this issue. We thank our Chapter Chair Dr Shiv Mohan and members of the Exe-Com for their constant support and guidance in releasing this Issue.

We are happy to bring to you reports on the host of events carried out by the Chapter during 2019, in the form of Workshops, distinguished lectures by national and international experts and other brain-storming activities. Dr. M. R. Sivaraman writes a summary of success stories of ISRO during the year. Dr. Keely Roth provides an industry perspective to GRSS activities in the form of an Interview and a talk, which are thought-provoking. We have included a link to the recording of the talk by her. We are happy to cover the golden jubilee year celebration of Apollo-11 landing on Moon with a special lecture by Dr. Anil Bhardwaj, Director, Physical Research Laboratory. Dr. Anup Das, a member of our editorial team has contributed a technical article on using SAR data for forest biomass computation.

A list of events lined up for 2020 by the Chapter is also included. Hope you will find this Issue as interesting and informative as our 2018 issue, if not better. The Society is fast expanding with the active support and participation from all our members and we sincerely express our thanks to all. We wish our readers a happy browsing and listening experience! We will be happy to receive your critics and comments for further improvements.

On behalf of the Editorial Team
Dr. Maneesha Gupta
Associate Editor

IEEE- Gujarat Section GRSS Chapter Members Meet at Aarya Grand Hotel , Ahmedabad on 3rd December 2019

From Chairman's Desk

Dr. Shiv Mohan

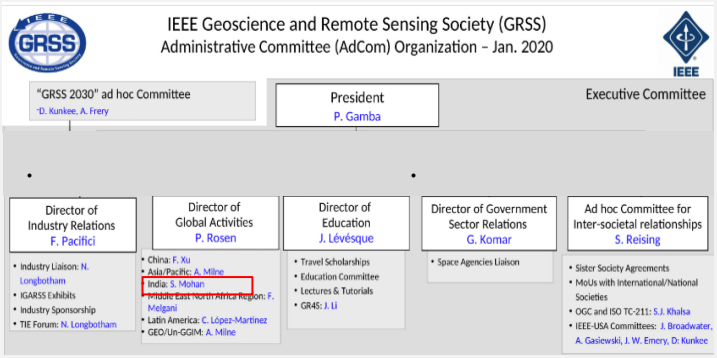
I am pleased to note the progress of our Chapter during the year with highest growth in membership as well as in number of activities. It may be noted that the GRSS chapter was initiated by a group of renowned scientists and professionals of Gujarat region in the month of May 2013. The Chapter represents members working in Geoscience applications representing various institutes like Space Applications Centre (SAC/ISRO), Physical Research Laboratory, CEPT University, Nirma University, Gujarat University, MS University, corporate sector and a freelancer volunteering for science and educational services. I am happy to note the contributions of members, in organizing various events in a smooth and professional manner. During the year, Society has served the purpose of bringing out professionals from international community under the distinguished lecture program or in the form of advanced training program. In addition, a popular lecture on lunar science was a great attraction for professionals and students. Members of the Chapter were enthusiastic about the international InGARSS 2020, planned at Ahmedabad. Among various activities, conducting interactive workshops involving academia, government and industry, is the first step towards involving industry as partner in our activities. All this is feasible by team effort of our members who have worked hard as IEEE volunteers of the Society. After overwhelming response from past newsletters, our editorial team has brought out this issue of 2019. I congratulate the editorial team for their consistent efforts in bringing out the issue in a comprehensive manner.

Dr. Shiv Mohan
Chairman, IEEE Gujarat Section Geoscience and Remote Sensing Society- Chapter
E-mail id: shivmohan.isro@gmail.com

Accomplishments- IEEE-GRSS Gujarat Chapter

Appointment: **Dr. Shiv Mohan** has been appointed as **IEEE GRSS Liaison for India region** (2019) by the IEEE president Dr. P. Gamba

IGARSS-2019 Travel Grant: **Dr. Maneesha Gupta**, Scientist, ISRO & IEEE-member was awarded travel grant for presentation of her work on "***Data Quality Evaluation of High Resolution SAR mode Data***" at **IGARSS 2019, Yokahama, Japan, 28th July to 2nd Aug 2019.**



Dr. Maneesha Gupta during Oral presentation and interacting with SAR experts at IGARSS-2019, Yokohama, Japan

Event Reports

IEEE-GRSS BOOTH ACTIVITY AT URSI CONFERENCE NEW DELHI, MARCH 11-14, 2019

The purpose of establishing a booth at URSI conference was to create awareness and promote the membership of IEEE-GRSS amongst the institutions within India. The idea of booth activity was suggested by Dr. Paul Rosen, Director of Global Activities, IEEE-GRSS and Dr. Shiv Mohan, IEEE GRSS Liaison coordinator for Indian region. IEEE-GRSS Gujarat members Dr. Aishwarya Narain and Mr. Savyasachi Goswami volunteered for the booth. On day-1, Dr. Shiv Mohan and Mr. Munir Mohammed, Sr. Program Manager, IEEE-India hosted the booth. Dr. Paul Rosen spent considerable time at the booth explaining to the visitors. He also presented details of NASA-ISRO joint project NISAR at one of the technical sessions at URSI 2019. The delegates visiting the booth were given a brief on chapters/ sections running in the country notably Gujarat, Bangalore, Bombay Delhi and Kolkata sections. In all, there were 50 visitors to the booth. Some of them were IEEE professional/student members representing various institutions/ chapters/ regions within the country and abroad.

Dr. Aishwarya Narain, Vice-chair, IEEE GRSS Gujarat Chapter with Dr Paul Rosen

More importantly the visitors were briefed on the six Technical Committees of GRSS dealing with specific areas of research viz., 1. Earth Science Informatics (ESI), 2. Frequency Allocations in Remote Sensing (FARS), 3. Geoscience Spaceborne Imaging Spectroscopy (GSIS), 4. Image Analysis and Data Fusion (IADF), 5. Modeling in Remote Sensing (MIRS), 6. Instrumentation and future technologies (IFT). And if interested they can explore and approach any one or more of the Technical Committees. We as members can also think of interacting with one or more of these technical committees. Visitors were also briefed about the procedures and the benefits of becoming an IEEE-GRSS member.

DISTINGUISHED LECTURE PROGRAM BY PROF. GUSTAU CAMPS-VALLS CEPT University, Ahmedabad June 22, 2019

Prof. Gustav Camps-Valls delivering Expert Lecture

The expert lecture on machine-learning for remote sensing data analysis was organized in collaboration with the Indian Society of Remote sensing (ISRS) on 22nd June 2019 at CEPT University, Ahmedabad. After introducing IEEE GRSS and ISRS, Prof. Gustau Camps-Valls was introduced to the participants. Following to that Prof. Camps- Valls presented an in-depth and elaborate understanding of machine learning technology, its applications and working case studies in the Earth orbservation domain. The session focused on remote sensing image processing chain, different strategies for feature extraction, classification, unmixing, retrieval and pattern recognition for remote sensing data analysis. Powerful methodologies for supervised classification of remote sensing data were discussed for extraction of knowledge from data, including interactive approaches via active learning, classifiers that encode prior knowledge and invariances, semi-supervised learning that exploit the information of unlabelled data, and domain adaptation to compensate for shifts in the ever-changing data distributions. Latest advances in the field of unmixing were reviewed, covering sparse approaches, spatial-spectral methods, and methods constrained by physical models. Furthermore, recent advances in bio-geophysical parameter estimation were also discussed. Beyond theory, results of recent case studies illustrating all the covered issues were presented. Tutorial based exercises were briefly discussed and shared with the participants for future reference.
Along with senior scientists from SAC-ISRO, PRL and PLANEX, a large no. of students, researchers, faculty members and industry representatives, attended the enlightening lecture followed by interaction with each other. The total number of participants were about 100, from various institues like GIT, Infocity Science College, SLTIET, ST IGCC, CHARUSAT, S&P Global, Nirma University, Gujarat University, Amnex Technologies Pvt. Ltd., CEPT, Institute for Plasma Research, Nascent Infotech, PDPU, and St. Xaviers College etc. The lecture was attended by about 100 particiapnts.

Group Photo after Distinguished Lecture Programme By Prof. Gustau Camps-Valls

POPULAR LECTURE - Celebration of 50 Years of Apollo landing at M. G. Science Institute, Ahmedabad, July 20, 2019

On the occasion of 50 years of moon landing, on July 20, 2019 a popular lecture on Exploring Moon was delivered by Dr. Anil Bhardwaj, Director, Physical Research Laboratory, Ahmedabad at M G Science Institute. Lecture covered various developments in lunar science since then which include the developments at ISRO. Lecture was well attended by about 150 participants representing research and academic institutes like ISRO, Physical Research Laboratory, M G Science Institute, Gujarat University, Nirma University and dominated by students. At the end of lecture, enthusiastic researchers interacted with speaker on various issues related to lunar exploration.

Dr. Anil Bhardwaj, Director, Physical Research Laboratory, Ahmedabad

Distinguished Lecture Program by Dr. Keely Roth, Senior Remote Sensing Scientist, The Climate Corporation at Nirma University, Ahmedabad, November 13, 2019

https://drive.google.com/file/d/1g-TSkHtTQ-p3lswqO4-oao9JGdGlRfc-/view?usp=sharing

Dr. Keely Roth, Senior Remote Sensing Scientist and Science Lead for Horticulture on the Geospatial Sciences team of The Climate Corporation, USA delivered an expert talk on November 13, 2019 at PG Seminar Hall, IT-NU. The activity was organized in collaboration with ISRS, Amedabad. Dr. Keely Roth had covered the basic concepts of remote sensing, sensors, data

Dr. Keely Roth delivering lecture

Dr. Keely Roth felicitated by Dr. Anup Das

Participants of the lecture

collection methods, platforms and data utilization in her lecture. She also shared her field experience and issues related to Ground Truth data collection. The lecture also focused on how to get the benefit from combining sensor data across temporal, spatial and spectral scales. The major focus of lecture was on selecting the appropriate sensor and trade-offs to consider, the common methods for vegetation characterization and how to use sensors and data fusion to leverage the strengths of multiple systems across various scales. The new sensor technology for GT collection was also discussed. She also explained briefly the significance of data fusion and machine learning in remote sensing applications. The lecture was attended by about 100 participants from various institutions including ISRO , CEPT University, PDP University, Gujarat University and Nirma University.

SAR Polarimetry Training workshop Ahmedabad, December 3-5, 2019

Dr. Carlos Lopez-Martinez, Universitat Politècnica de Catalunya, Barcelona, Spain delivering a lecture

Dr Kostas Papathanassiou, DLR, Germany delivering a lecture

A training workshop on SAR polarimetry- Basics and Applications was organized during December 3-5, 2019 at Aarya Grand Hotel, Ahmedabad. Faculty members were Dr. Kostas Papathanassiou, DLR, Germany and Dr. Carlos Lopez-Martinez from Universitat Politècnica de Catalunya, Barcelona, Spain. About 70 particiapnts from different organizations spread across India attended the training workshop. Dr. Carlos Lapez-Marinez conducted the training workshop on first two days. On the first day, he covered topics on radar basics, SAR polarimetry, SAR data types, speckle filtering and decomposition theory. On the second day he continued with the topics on polarimetric decomposition, classification and applications. On day 3, Dr. Kostas Papathanassiou, delivered lectures on Polarimetric interferometry and polarimetric SAR tomography.

Participants of the SAR Polarimetry Training workshop

Group Photo showing the faculty and the participants

Symposium on Industry Academia Collaboration for Geospatial Technologies - CEPT University Ahmedabad, December 10-11, 2019

A symposium on Industry-Academia collaboration for Geospatial technology was organized during December 10-11, 2019 at CEPT University, Ahmedabad. Experts from academia, government and industry discussed about the emerging trends in geospatial industry and the role of academia in reaching those goals. In the symposium discussions were also held on vision fo GIS industries and trends deciding roadmaps in GIS to have better visibility in working together for the benefit of both academia and industry.

Addressing the participants during the symposium Dr. Bindi Shastri (Left) and Dr. Shiv Mhan (Right)

Group Photo showing participants of the symposium

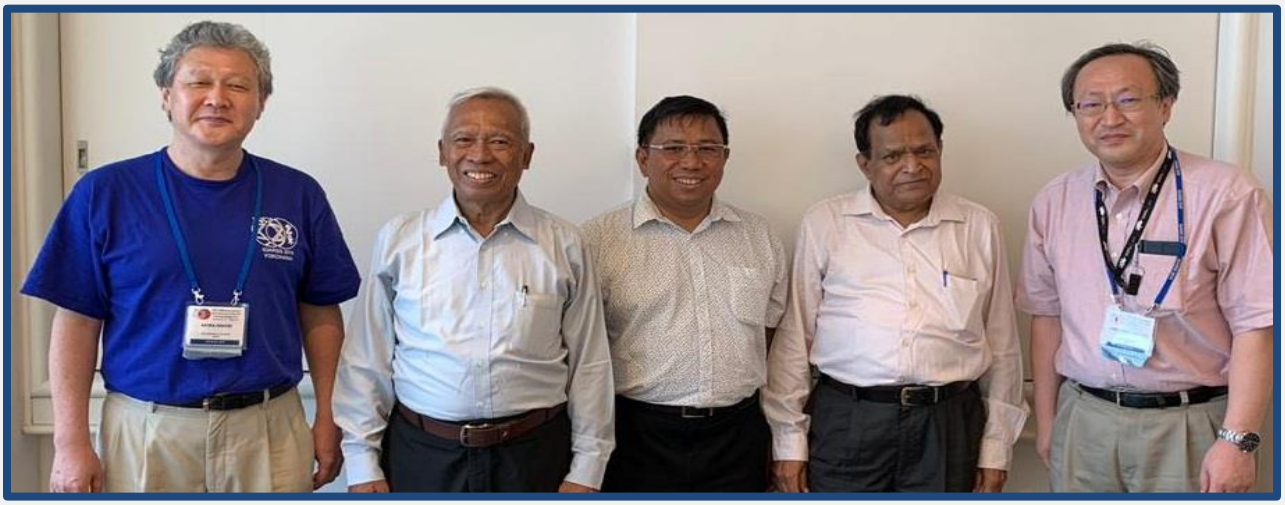
Chapnet Program at Tokyo, Japan, August 3-4, 2019

The CHAPNET program of IEEE GRSS (Gujarat - India, Japan and Indonesia) was proposed as joint program for a presentation in the International Polarimetric SAR Workshop in Tokyo 2019, which was co-organized by National Institute of Information and Communications Technology (NICT), Japan. Chairs from three chapters presented their contributions to the global community. New methods have been evolved in the ChapNet in the field of Microwave Remote Sensing, and the way to enrich the information obtainable through various transmission techniques and big data processing. Following presentations were made during the session:

- Equatorial-satellite-constellation communication for disaster mitigation by Dr. Wahyudi Hasbi, LAPAN, Indonesia
- Study of HAPS inclusion for future integrated satellite network by Dr. Arifin Nugroho, Indonesia
- Towards multi-parameter SAR applications: Indian context by Dr. Shiv Mohan, India

Global experts meet at International SAR polarimetry workshop, Tokyo (3-4 Aug 2019)

Prior to the special session, a meeting among the members of Chapnet from Gujarat, Indonesia and Japan was held at Yokahama on 1st Aug 2019. The members discussed the continuity of program and expressed concern for participation in InGARSS 2020 conference.



From Left to Right; Prof Akira Hirose, Japan, Dr. Arifin Nugroho, Indonesia, Dr. Wahyudi Hasbi, Indonesia and Dr. Shiv Mohan, India

Gujarat Chapter in Various IEEE-GRSS Meets

Presentations in Chapter Chairs meet, Yokahama, Japan, July 30, 2019

As is the tradition, for exchanging information and discussing about problems and solutions, a meeting of chapter chairs was organised at Yokahama on July 30, 2019. Chapter activities were presented by the IEEE GRSS member Dr. Maneesh Gupta from ISRO, Ahmedabad . Presentation was highly appreciated by most participants.

Dr. Maneesha Gupta presenting the Chapter activities in Chapter Chair Meet during IGARSS-2019, Yokohama, Japan, July 30, 2019

Indian Chairs meet 2019, New Delhi, March 10

Towards extending the support for GRSS activities in India, Chapter contributed towards formally meeting Chapter chairs on March, 10 2019 at India Habitat Centre, New Delhi. One of the agenda related to future directions for activities which could be done jointly and a proposal for international conference.

Chapter Chairs Meeting on 10th March 2019

Indian Chairs Meet 2019, Bangalore, India, July 13 and November 5

Global and Indian IEEE GRSS Leaders met on July 13, 2019 and November 5, 2019 in Bangalore for planning Indian Geoscience and Remote Sensing Symposium (InGARSS-2020) in Ahmedabad, Gujarat in line with the IGARSS. InGARSS would provide the Indian researchers a platform to showcase their researches before a diasphora of Global and Indian researchers similar to the Global symposium.

Chapter Chairs Meeting on July 15, 2019 at IEEE (India), Bangalore

Chapter Chairs Meeting on November 5, 2019 at IEEE (India), Bangalore

Meeting for Organizing Industry- Academia Symposium: CEPT University Ahmedabad, June 6, 2019

Meeting was held on June 6, 2019 between the IEEE-GRSS Gujarat members and the organizers from CEPT University to discuss and plan events related to Industry-academic interface symposium at CEPT University, Ahmedabad. Agenda of the symposium, tentative schedule and probable speakers were worked out during the meeting.

Dr. Aishwarya Narain, Vice-Chair, IEEE GRSS, Dr. Shiv Mohan, Chair, IEEE GRSS and Prof. Anjana Vyas, CEPT University, Ahmedabad with other volunteers

Members' meeting, June 22, 2019

Meeting of the IEEE GRSS Gujarat Chapter's professional and student members was held at hotel Planet Landmark, Ahmedabad on June 22, 2019. Primary agenda of the meeting was towards planning the activities and encouragements of students for initiating GRSS student branch at CEPT University. It was decided to allow entry of members free of cost during the year's activities.

Members' meeting, December 3, 2019

Meeting of the GRSS members was organised on December 3, 2019 with the visiting faculty and participants of the SAR polarimetry workshop held at Ahmedabad during December 3-5, 2019. Among the various issues the meeting also discussed available opportunities for the young members and their mentoring.

IEEE Gujarat Section GRSS Chapter Members' Meet at Aarya Grand Hotel on Decembe 3, 2019

Glimpses of ISRO's Success Story in 2019

Compilation: Dr. M. R. Sivaraman
(Formatted by Editor)
dr.manjeri.r.sivaraman@gmail.com

Year 2019 is an extra-ordinary year for ISRO. Here are some glimpses of space applications, satellite missions and rockets that launched them:

Space Applications: ISRO developed **Indigenous Satellite Navigation System "NAVIC"** gets recognized as part of future Global Navigation Satellite System (GNSS). Mobiles in future will carry indigenously made NAVIC chips. ISRO started using indigenously made navigation processor chips in rockets for tracking.

Satellite Missions and Applications:

Earth-Observation Missions:

RISAT-2BR1 launched on December 11, 2019: The satellite will provide services in the field of Agriculture, Forestry and Disaster Management.

Cartosat 3 launched on Nov. 23, 2019: A third generation advanced satellite, having high resolution imaging capability. Cartosat-3 will address the increased users' demands for large scale urban planning, rural resource and infrastructure development, coastal land use and land cover etc.

RISAT-2B launched on May 22, 2019: It is an Active SAR (Synthetic Aperture Radar) Imager and has all-weather as well as the day-and-night SAR observation capability in applications such as agriculture, forestry, soil moisture, geology, sea ice, coastal monitoring, object identification and flood monitoring; and also for military surveillance.

GSAT 31 launched from Kourou launch base, French Guiana by Ariane 5 on Feb. 6, 2019 to provide continuity of operation of the Ku-band transponder for communication over Indian mainland and islands.

Moon Mission:

Chandrayan 2: ISRO's most ambitious mission to date, to explore south pole of the Moon, using ISRO's most powerful rocket to date, GSLV-Mk III – M1. Everything went off well as regards the moon mission was concerned till the fateful early morning of Sep. 7, when Vikram that was racing to set its foot on the moon crashed into lunar surface at a great speed and broke into pieces. The Orbiter placed in its intended orbit around the Moon will enrich our understanding of the moon's evolution and mapping of the minerals and water molecules in polar regions, using its eight state-of-the-art scientific instruments. The Orbiter camera is the highest resolution camera (0.3 m) in any lunar mission so far, providing high resolution images which will be immensely useful to the global scientific community.

Launch Vehicles:

GSLV Mk III: Geosynchronous Satellite Launch Vehicle Mark III, also referred to as the Launch Vehicle Mark 3 (LVM3), is a three-stage medium-lift launch vehicle developed by ISRO. Primarily designed to launch communication satellites into geostationary orbit, it is also identified as launch vehicle for crewed missions under the Indian Human Spaceflight Programme and dedicated science. The GSLV Mk III has a higher payload capacity than the similarly named GSLV Mk II. It will be used to carry Gaganyaan, the first crewed mission under Indian Human Spaceflight Programme successfully launched Chandrayan 2 on Jul. 22.

The 50th PSLV rocket launched the satellite RISAT-2BR1.

ISRO also developed and launched two new variants of the rocket **PSLV-DL** (with two strap-on motors) and **PSLV-QL** (with four strap-on Motors).

ISRO gave finishing touches to its new rocket: Small Satellite Launch Vehicle (**SSLV**) with a capacity to carry 500 kg, to be flown next year.

Other Highlights:

- In order to involve Private Sector in making rockets and also taking over the commercial activities of Antrix Corporation, "**New Space India Limited**" (NSIL) was formed.

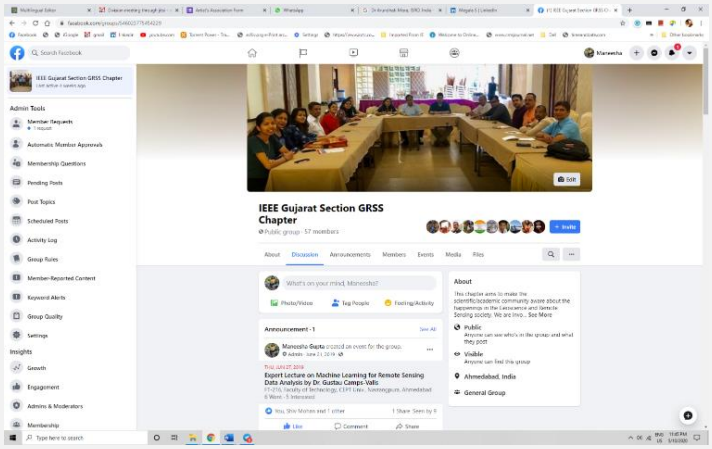
- ISRO set up **Human Space Flight Centre for** training Astronauts (also called Vyomanauts) at Bangalore. This centre and Glavcosmos, which is a subsidiary of the Russian state corporation Roscosmos, signed an agreement on Jul. 1, 2019 for cooperation in the selection, support, medical examination and space training of four Indian astronauts.

- An **ISRO Technical Liaison Unit (ITLU)** was setup **in Moscow** to facilitate the development of some key technologies and establishment of special facilities which are essential to support life in space.

- ISRO signed a **memorandum of understanding with** the Indian Air Force's **Institute of Aerospace Medicine** (IAM) to conduct preliminary research on psychological and physiological needs of crew and development of training facilities.

- **Astronaut training:** Till Sep. 2019, level 1 of astronaut selection process was completed in Bengaluru. Selected Test Pilots underwent physical exercise tests, lab investigations, radiological tests, clinical tests and evaluation on various facets of their psychology. By Nov. 2019, the Indian Air Force had selected 12 potential Gagan Yatris (astronauts) who will then go to Russia for further training in two batches. As selection criteria require test pilot experience, any females will not be part of the first Indian crewed spaceflight. First crewed flight will consist of a crew of three with one backup and this team of four will go to Russia for astronaut training.

For Association and information with IEEE-GRSS, follow us at- facebook/website



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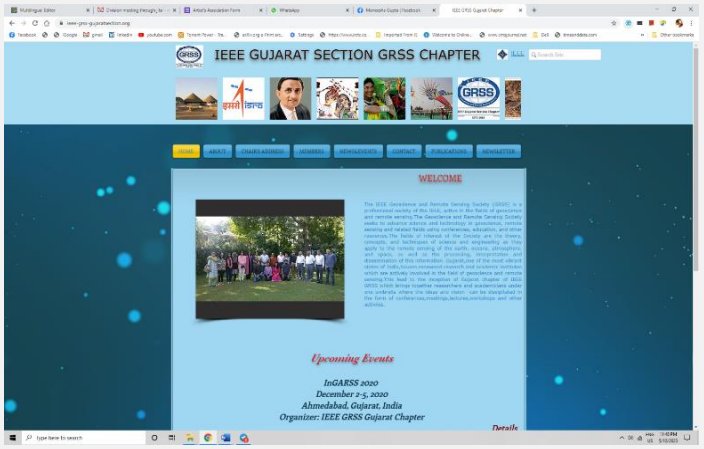


https://www.ieee-grss-gujaratsection.org/

An Interview with Dr. Keely Roth

Dr. Keely Roth, Lead Remote Sensing Scientist, The Climate Corporation, San Francisco, CA, USA

Dr. Keely Roth is a Senior Remote Sensing Scientist and Science Lead for Horticulture on the Geospatial Sciences team of The Climate Corporation. She is from San Francisco, CA, and has 10+ year experience in remote sensing research and geospatial analysis. In her role at The Climate Corporation, she designs and leads research projects aimed at improving our ability to measure and map crop health during the growing season using field data and remotely sensed imagery from UAVs, planes, and satellites. She also leads the research program for Horticulture, including fruits, vegetables, and specialty crops. In her work, she is especially focused on and committed to applying the best remote sensing scientific principles to developing models and generating valuable data layers for her scientific colleagues as well as for farmers within the Climate FieldView platform. Prior to joining The Climate Corporation, Keely was a postdoctoral research scientist in the Center for Spatial Technologies and Remote Sensing Lab at UC Davis. Her research was part of the NASA HyspIRI campaign to evaluate the capabilities of a spaceborne imaging spectrometer mission for characterizing plant functional traits across ecosystems. In her graduate research, she worked on projects related to measuring forest biomass, mapping ecosystem species composition and phenology, and tracking post-fire vegetation recovery. While in academia, she worked extensively with multispectral, hyperspectral, and lidar remote sensing data and led 100+ field data collection campaigns to design, develop, and validate remote sensing models. During this time, she gained a deep understanding of statistical models, machine learning, and image processing techniques. She specializes in imaging spectroscopy and has experience with physical process models. We are fortunate to have her views for our readers during her visit to India during Nov. 2019

1. **Editor: What if the advances in (i) AI, particularly Deep Learning; (ii) Big Data Analytics; (iii) UAVs for taking local images, and (iv) online accessibility of the data archive of both optical and microwave remote sensing data; are all used together, how do you foresee the future of remote sensing?**

KR: I believe this is the future for remote sensing applications. Each of these areas are rapidly developing both in terms of hardware and software. Multi-scale remote sensing data combined with the most powerful AI/DL/ML algorithms allow us to more fully address some of the most challenging issues in Remote Sensing applications. Online accessibility and in-the-cloud processing will, I hope, lead to wider access to these data overall and thus, increase the speed of innovation in our discipline.

2. **Editor: At the Climate Corporation, do you generate and/or send customised advisories to individual/group of farmers? If yes, could you please elaborate on how it is done. What are the contents? What is the format? What is the mode of delivery, etc.?**

KR: We do generate and provide customer-specific data and model outputs. For broad-acre row crops (e.g., maize, soybean, cotton), this is done through our Climate FieldView ™ app. The app allows farmers to collect and upload their farm management data (planting, fertilizer and pesticide applications, and yield). We combine this information with other environmental data, such as weather, satellite imagery, and soil characteristics to build our own scientific analytics. Within the app, the farmer can access, organize, and visualize all the data layers spatially as well as see the outputs of the models we run. The main app has both web browser and mobile access, and many of our customers use our FieldView ™ Cab app for real time data collection and mapping while they are in the field.

3. Editor: Which, in the past three-to-five years, do you consider as the most beneficial research to humankind in remote-sensing? Please elaborate.

KR: I think the most valuable remote sensing research for humankind in recent years has been in the area of disaster response and management. The development of satellite constellations with very high resolution visible imagery, the explosion of crowdsourcing applications for labeling imagery, and advances in Deep Learning algorithms have enabled us to rapidly map critical features and provide near real time support to first responders. The use of UAVs/drones in this area has also been an incredible advance for helping responders quickly understand on-the-ground conditions and manage their work more safely.

4. Editor: What are the challenges working with optical and SAR remote sensing data in various spectral and spatial resolution for plant ecosystem?

KR: Both optical and SAR data have different advantages and disadvantages for mapping plant ecosystems. These sensor-specific pros and cons are also related to tradeoffs in spectral and spatial resolution of the data collected. For optical data, many systems exist with allow us to collect very fine spatial or spectral data, but sometimes these systems have lower coverage of the Earth's surface. Additionally, cloud cover will always remain a limitation for using these systems to map and monitor vegetation. However, optical systems provide a direct physical link to many of the vegetation characteristics we want to measure. SAR systems are rapidly advancing, and we see their application within vegetation growing. Processing and clear interpretation of SAR metrics remain challenges to using this type of data more broadly.

5. Editor: What is your message to our young student members of IEEE-GRSS Gujarat section?

KR: Keep pursuing the hard research problems! We have so many problems in the world. Remote sensing can help address, so we need you to continue to advance the science. As you work on your research, try to think critically about how it can be applied in the real world. This will help you refine your analysis and make better decisions regarding the data you work with and the methods you apply. Finally, do not be afraid to ask for feedback and help. Science is stronger when more eyes and brains have considered it.

Dr. Keely Roth with Chapter Chair Dr. Shiv Mohan, Editor-Dr. R. Nandakumar, and Associate Editor- Dr. Maneesha Gupta

Technical Article

SAR based Approach for Mapping and Monitoring Forest Biomass in India

Anup Kumar Das, IEEE Senior Member, Space Applications Centre, ISRO

Accurate measurement and monitoring changes in forest biomass is important for forest conservation and assessment of carbon stock and carbon fluxes from the forest ecosystems. In India, periodic estimation of forest biomass in regional to national level has been a long standing requirement as the country is gearing up for implementation of UN's Reducing Emissions from Deforestation and forest Degradation-plus (REDD+) programme. There have been efforts to estimate forest above-ground biomass (AGB) at local to regional levels by many using satellite remote sensing technology. However, estimation of forest AGB at state level or national level and production of forest aboveground biomass maps of India are yet to achieve maturity. One of the straight forward method of measuring forest biomass is to harvest the trees over a unit area and record the dry-mass of the vegetative matter. However, such methods are not feasible due to the labour intensive process and restrictions on destruction of forest vegetation. Hence, indirect methods using tree allometry and remote sensing based models are considered for estimation of forest biomass. There have been several assessments of forest biomass and forest carbon stock globally or regionally over tropical regions, made by researchers using space borne remote sensing data (Saatchi et al. 2011, Thurner et al. 2014, Santoro et al. 2015, Avitabile et al. 2016). Many of these researchers have agreed that synthetic aperture radar (SAR) provides optimum dataset for retrieval of forest AGB provided good amount of and reliable ground data on vegetation type, density and tree allometry are available.

SAR data has shown great potential in retrieval of forest AGB due to its capability of all-weather, day-night imaging and ability to penetrate vegetation canopy to provide more dynamic range for vegetation growth variables as compared to optical data. SAR signals in longer wavelength (such as L and P-band) have ability to penetrate deeper inside the vegetation canopy and produce more sensitivity to the biomass of higher densities, hence are widely used for retrieval of forest AGB. Several methodologies for biomass estimation have been reported in recent literatures but no method has been projected to be robust for national level biomass estimation, especially for India where forest vegetation has high diversity due to varied climatic conditions, physiography and topography. There is also no clear view on how carbon pools and their fluxes should be reported and what the accuracy and uncertainty of biomass monitoring might be. Therefore, biomass mapping has become an urgent need to assess and produce data on forest carbon stocks and the change in carbon stocks at national level. The article discusses possible methods and availability of suitable SAR data for establishing an operational methodology for forest AGB estimation over Indian region.

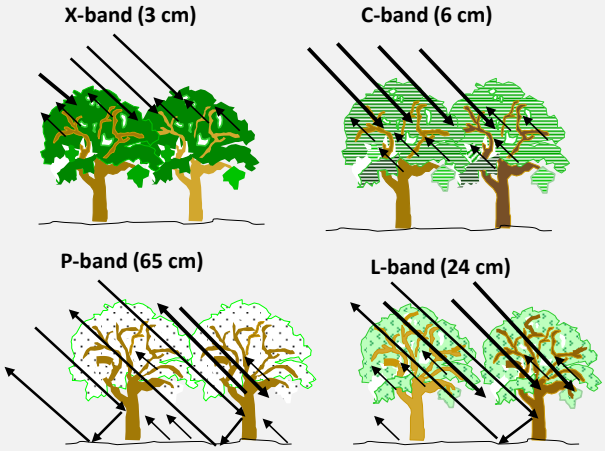


Figure 1. Schematic diagram showing SAR sensitivity to forest structure and penetration into the canopy at various wavelength bands used for airborne and spaceborne remote sensing

Radar Sensitivity to Forest Structure and Biomas

Radar measurements are strongly dependent on the structure, dielectric properties of vegetation components and underlying soil surface. Radar backscatter measurements provide strong sensitivity to forest structure and biomass. This sensitivity is dependent on several factors including vegetation structure, moisture content, biomass density and wavelength and polarization of radar signal (Figure 1). While the sensitivity at X and C bands is drastically

reduced to a biomass range of 40-50 tons/ha, the sensitivity at L-band is observed upto a biomass in the range of 100 to 150 tons/ha and at P-band the backscatter sensitivity is significant up to a biomass range of 200 to 300 tons/ha (Saatchi *et al.* 2011b, LeToan *et al.* 2011). By adding interferometric radar techniques as in PolInSAR and TomoSAR measurements, the sensitivity of radar sensors may increase over the entire biomass range in tropical forests (Hajnsek *et al.* 2009). SAR backscatter measured in cross polarizations (HV or VH) is primarily returns from the vegetation canopy and hence, it is more sensitive to forest biomass as compared to the co-polarization backscatter (HH or VV), which is more sensitive to the vegetation stem and ground scatterings. (Figure 2).

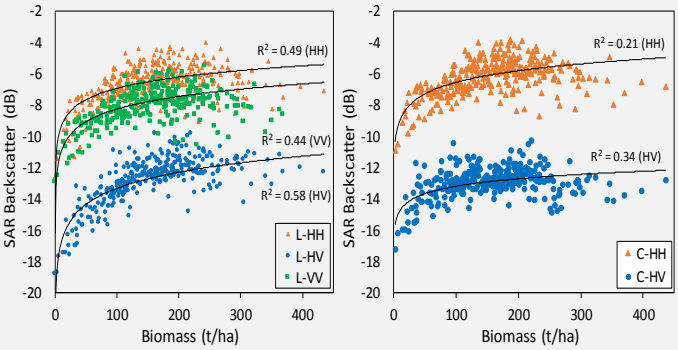


Figure 2. Radar backscatter sensitivity to forest above-ground biomass in different polarizations at L and C-band. Biomass values measured over 0.1 ha inventory plots in Karnataka, India is considered.

State of Forests in India

India has a forest cover of 71.22 m ha comprising 21.67% of its geographical landmass (as per ISFR 2019, FSI). The major forest types of India are (1) moist tropical, (2) dry tropical, (3) montane sub-tropical, (4) montane temperate and (5) alpine forests apart from mangrove forests, distributed over 15 physiographic zones in India. As per India State of Forest Reports (ISFR), forest cover in India is slowly but consistently increasing since 1987 and so also the forest carbon stock (Table-1). A major portion of Indian forests (approx. 70%) consists of deciduous or semi-deciduous vegetation, which has distinct leaf-on (or wet season during May to November) and leaf-off (or dry season during December to April) period associated with the phenology. The leaf-on and leaf-off periods vary according to the climatic variations at different regions in India. Forest survey of India (FSI) is responsible for enumeration of forest vegetation of India and produces biennial estimates of forest cover and forest carbon stock. While, the forest cover map is generated using remote sensing images at 25m grid, forest carbon stock is grossly estimated from limited sampling plots distributed over different vegetation types in India. Recently, the need for spatially explicit remote sensing based estimation of forest biomass and forest carbon stock has gathered momentum as India is readying to meet various climate related challenges. In this context, spaceborne SAR based approaches have been emerged as the most viable solution for mapping and monitoring forest biomass and carbon stock.

Table 1. Profile of forests in India during 1987 - 2019. Source: India State of Forest Report, Forest Survey of India (FSI)

	Forest cover (in Million ha)					Forest Carbon Stock (Gt)	
Year	Dense Forests[1]	Open Forests	Mangroves	Total	% of Geog. area	in AGB	Total[2]
1987	36.14	27.66	0.40	64.08	19.49	N/A	N/A
1989	37.84	25.74	0.42	63.88	19.43	N/A	N/A
1991	38.50	24.99	0.42	63.93	19.45	N/A	N/A
1993	38.55	25.02	0.42	63.93	19.45	N/A	N/A
1995	38.57	24.93	0.45	63.88	19.43	1.784	6.245
1997	36.72	26.13	0.47	63.33	19.27	N/A	N/A
1999	37.73	25.50	0.48	63.72	19.39	N/A	N/A
2001	41.68	25.87	0.45	67.55	20.55	N/A	N/A
2003	38.85	28.92	0.44	67.78	20.64	N/A	N/A
2005	38.72	28.98	0.44	67.70	20.60	1.983	6.622
2009	40.25	28.84	0.46	69.09	21.02	N/A	N/A
2011	40.42	28.78	0.46	69.20	21.05	2.101	6.663
2013	40.22	29.56	0.46	69.78	21.23	2.192	6.941
2015	40.12	30.04	0.47	70.16	21.34	2.22	7.044
2017	40.64	30.17	0.492	70.82	21.54	2.237	7.082
2019	40.77	30.45	0.497	71.22	21.67	2.256	7.124

[1] *This includes very dense forests and moderately dense forests.*
[2] *This includes AGB, BGB, Deadwood, Litter and Soil Organic Carbon (units in Giga ton)*
N/A: Data not available

SAR based Approach for Estimation of Forest Biomass

Selection of suitable SAR data and inversion algorithm is vital for accurate estimation of forest AGB. In India, SAR data acquired during dry season (leaf-off period) provide higher backscatter dynamic ranges within the forest vegetation compared to the data acquired during wet season (leaf-on period) and produce better estimation of above-ground vegetation biomass (Das and Patnaik, 2017, Das *et al*, 2018). Various algorithms are reported in literature, for estimation of forest AGB using SAR data, however, all the studies have followed a generalized methodology that is depicted in a flow chart in the Figure 3. The important components of this approach are: selection of proper SAR data; external DEM for topographic correction of SAR data; forest inventory data for ground measured forest biomass and vegetation fraction; biomass inversion models; and reliable and up-to-date forest mask.

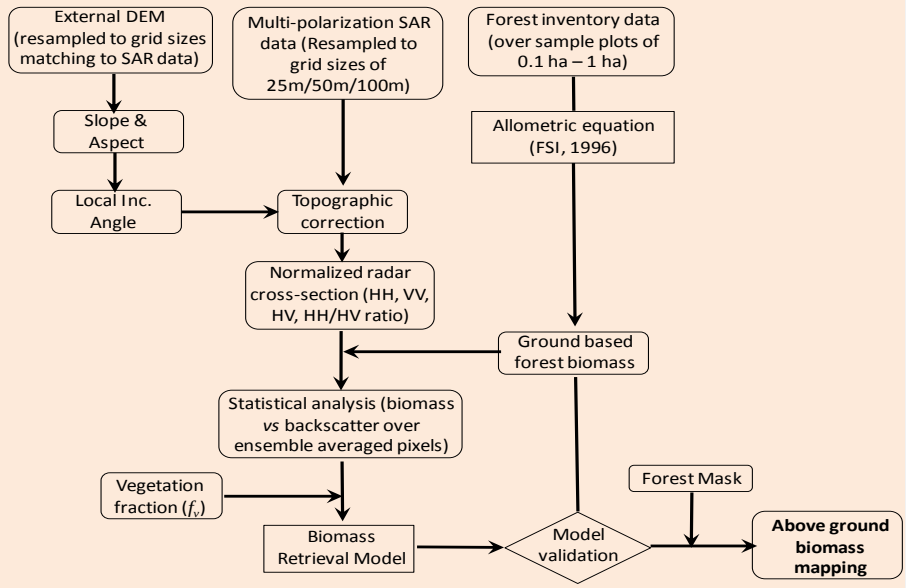


Figure 3. Methodology for biomass estimation

Available SAR Data and Digital Elevation Model

Due to the different sensitivities of SAR backscatter to forest AGB at different frequency bands, combination of multi-frequency (such as C-band and L or P band) SAR data is more suitable for retrieval of wide range of forest AGB densities (Sinha *et al*., 2019). Currently, L-band dual-pol (HH+HV) SAR data of ALOS-PALSAR-1 & 2 (Shimada *et al*., 2014) and C-band dual-pol (VV+VH) SAR data of ESA's Sentinel-1 are the most valuable data, freely available, for forest AGB estimation. Apart from that, C-band SAR data from Indian RISAT-1 acquired in Medium Resolution ScanSAR mode (MRS) in HH+HV polarization at 18m spatial resolution is also available over Indian region for the years 2012-2016 at a nominal cost from National Data Centre NDC), NRSC (http://www.nrsc.gov.in/). In future, space borne SAR missions such as German's L-band TerraSAR, NASA-ISRO L & S band NISAR and ESA's P-band BIOMASS will provide valuable data for forest above-ground biomass estimation.

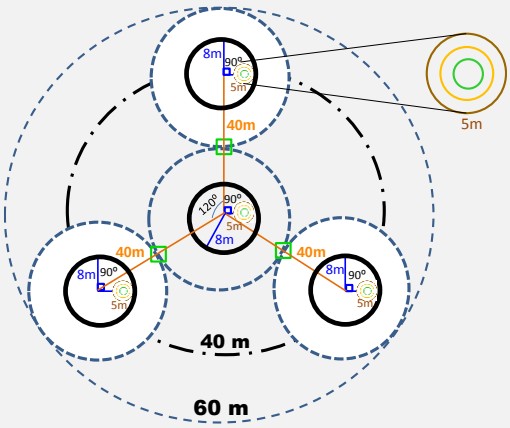


Figure 4. New NFI design for ground data collection: 60m radius (1.13 ha) circular plot for qualitative information like – land use, crop composition, origin of stand, fire incidents, soil, regeneration, grazing etc. and cluster of 4 sub-plots of 8m radius are four sub-plots of 8m radius are for tree measurements - like stem diameter at breast height, tree height, species name, crown-diameter etc.

While SRTM DEM and NASA DEM are generated from C & X band SAR data, DEM from ASTER, ALOS and Cartosat are generated from optical stereo image data. High resolution DEM data (10 m or higher) from Indian Cartosat satellite and German TerraSAR satellite can be purchased from the respective agencies.

Forest Inventory Data

Information about vegetation allometry parameters over fixed dimension sampled plots over forest vegetation is important for accurate estimation of ground based vegetation AGB. This data is used to train an inversion model to predict AGB over unknown areas. There are various methods for selection of sample inventory plots depending on type of vegetation concerned. Size of forest inventory plots as reported by various researchers varies from 0.1ha to 1ha of circular, rectangular or square shaped plots. There are few useful documents and manuals that provide details of methods and instructions for forest inventory data collection (FSI, 2002; Condit, R., 2008; FAO, 1981; Kauffman and Donato, 2012). Measurement of tree allometric parameters within an inventory plot and use of appropriate species specific volumetric equations and wood density is vital for estimation of above-ground dry biomass (expressed in tons/ha) over an inventory plot. The species specific volumetric equations of trees and wood density in Indian forests are available in various literatures. One of the most extensive compilations can be found in FSI, 1996. FSI collects ground measured data of different vegetation and soil parameters over Indian forests through sample plots laid over forested regions uniformly distributed over India and maintains national forest inventory (NFI) database. Recently, FSI has modified the NFI design strategy by adopting circular inventory plots and increasing the number and frequency of measurements over the plots in order to cope with the global standards of forest cover, livestock and forest carbon mapping and reporting (ISFR, 2019) (Figure 4).

Biomass Inversion Model

There are several radar biomass models are being used by the researchers. Statistical models such as linear, non-linear regression models and semi-empirical models using single or multiple variables like SAR backscatter intensity at different frequencies and polarizations, radar vegetation indices, polarimetric indices are more commonly used due to its simplicity in implementation. There are also radar physical models that are often complex in formulation and include a large number of variables covering the remote sensing sensor characteristics, the geometry of measurements, and the forest characteristics (Saatchi, 2019). Biomass maps have also been generated using nonparametric approaches such as interpolation, co-kriging, classification, decision rule techniques, and machine-learning approaches as in the Random Forest, Support Vector Machine or neural network.

Development of biomass inversion models are based on the predominant scattering contributions from forest vegetation, which can be represented by the following equation

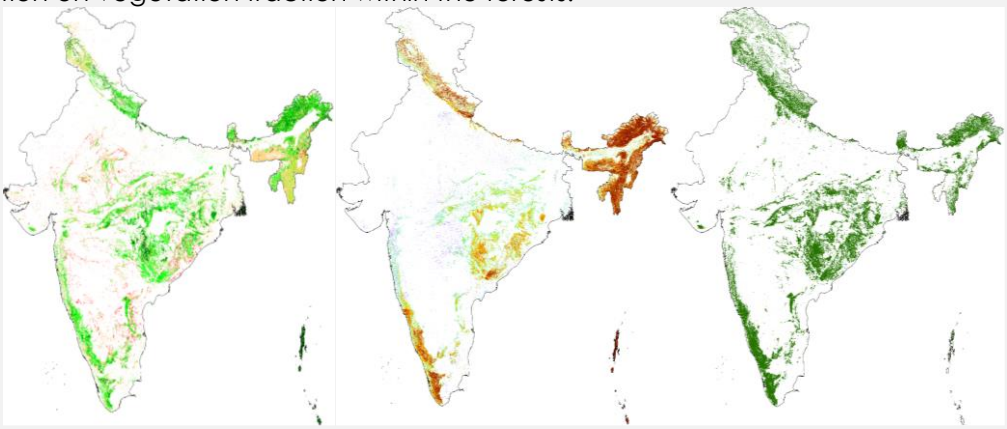
$$\sigma_{pq}(b) = f_{veg} A_{pq}\left(1 - e^{-B_{pq} b}\right) + f_{veg} C_{pq} b^{\alpha_{pq}} e^{-B_{pq} b} + (1 - f_{veg})\sigma_{pq}^{bare}$$

Where f_{veg} is the vegetation fraction of a pixel. f_{veg} = 1 for pixels fully covered by vegetation, p and q are the H and V polarization, α_{pq} is the biomass power factor which depends on polarization. b is the aboveground live biomass (AGB) expressed in tons/ha, finally, A_{pq}, B_{pq}, C_{pq} are the calibration coefficients which are calibrated for specific ecoregions and/or forest types. Here, the first term denotes the volume scattering from the forest vegetation, second term represents multiple scattering from ground-vegetation and the third term corresponds to the scattering from ground, which has dependence on soil moisture and surface roughness. From this relation, various biomass inversion models have been developed for estimation of AGB. SAR cross-polar backscatter (HV or VH polarization) shows higher sensitivity to vegetation biomass, hence considered as the most preferred parameter in biomass inversion models.

Forest Mask and Vegetation Fraction Data

Forest / non-forest mask is important for generation of forest AGB maps. Many of the forest biomass retrieval models use forest vegetation fraction information as percentage of vegetation within image resolution cell (pixel) for estimation of AGB. Forest Survey of India (FSI) generates biannually the forest cover map of India at 24m pixel spacing using optical satellite data (http://fsi.nic.in/) (Figure 5). This data serves as the most authentic forest cover mask of India. FSI forest cover presents forest cover with vegetation fraction

as 0-10% (scrubland), 10-40% (open forest), 40-70% (moderately dense forest) and 70-100% (very dense forest). Global forest cover for the year 2000 and forest cover gain and loss maps up to the years 2012 & 2017, respectively have been generated by Hansen *et. al.*, 2013 at the University of Maryland using Landsat data at 30m pixel spacing. The data provides forest vegetation fraction in the range of 1% - 100%. Forest cover map of India can also be obtained freely from global forest/non-forest product generated for ALOS-PALSAR dual-polarization data at 25m pixel spacing (Shimada, *et al.*, 2014). However, the data doesn't provide information on vegetation fraction within the forests.



India Forest Cover: FSI-2015
4 vegetation fraction classes:
10%; 40%; 70% & 100%
(Source: FSI-SFR-2015)

India Forest Cover: Hensen-2000
100 vegetation fraction classes:
1% - 100%

India Forest Cover: ALOS-fnf-2015
No vegetation fraction classes:
Only 0% & 100%
(Shimada, et al., 2014)

Figure 5. Available forest cover maps over Indian region.

Note: Updated forest cover maps from FSI is available for the years 2017 and 2019 and the same generated from ALOS-PALSAR-2 data is available for the years 2016, 2017 and 2018.

Using the above approach forest AGB maps of Indian states have been generated through regression based model of multiple variables using L-band (ALOS-PALSAR) and C-band (RISAT-1 and Sentinel-1) data. Forest AGB maps of Gujarat and Karnataka states generated for the year 2016 are shown here (Figure 6). The maps show regions of high biomass densities (more than 120 t/ha) in magenta colour. It is evident from the maps that SAR data in L or C band are unable to characterise forests of high biomass densities through regression models. SAR data in P-band and SAR data combined with lidar data is expected to produce better AGB estimation over high biomass regions. Alternatively, techniques like Polarimetric Interferometric SAR (PolInSAR) and SAR Tomography may be used to address forests of high biomass densities.

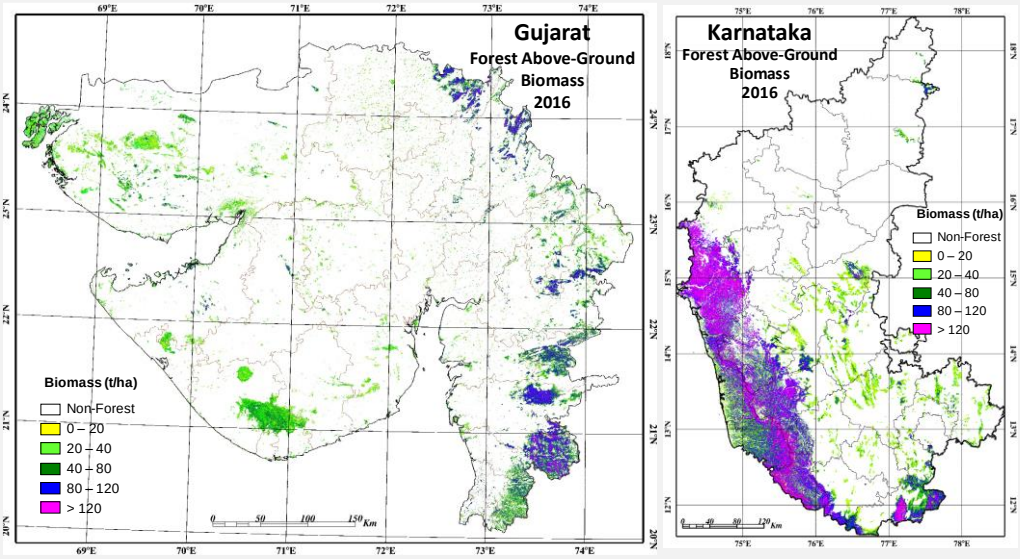


Figure 6. Forest above ground biomass (expressed in t/ha) map of Gujarat and Karnataka states derived from combination of C-band (RISAT-1) and L-band (ALOS PALSAR-2) SAR data acquired during 2016

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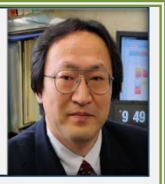
Feedback on Previous Issue

Impressive as always !

Paul Rosen
JPL – NASA, USA

Your chapter is very active !

Hiroyoshi Yamada,
Niigata University, Japan



It is very informative and well done !

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It is really a great work!

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India has a lot going on!

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SAC-ISRO, Ahmedabad

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Expert lecture by Dr. Steve Diggs on data management, ESIP, USA	Jul. 2020
IEEE Gujarat Section GRSS Chapter Members meet	Jul. 2020
Exposure program on Remote sensing for undergraduate students	Aug. 2020
Mentor program for students:	Aug. 2020
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